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REPORT ON UNITED STATES - NEW ZEALAND SOLAR ECLIPSE PROJECT

BY

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National Aeronautics and Space Administration

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SUMMARY

During the May 1965 total solar eclipse, in a joint United States - New Zealand operation, six Boosted Arcas rockets were successfully fired within 120 minutes from a remote location in Northern New Zealand. Five rockets were fired from a single launcher, while the last rocket was held in a ready condition and fired from a second launcher. Each rocket payload comprised a 12-pound miniaturized instrumentation system designed to gather and telemeter lower ionosphere electron and ion density data. Prior to this operation, the desires of the scientific community to launch a large number of rocketborne experiments during special scientific phenomena were generally restricted to existing ranges.

This report discusses the operational aspects of the eclipse project, examines the airborne and ground based electronic systems, and deals briefly with the installation and operation of the Boosted Arcas rocket system. Prelaunch and countdown preparations are supplied and sample radiation patterns for a dipole antenna enclosed within a plastic nose cone are included in an appendix. The report is not intended to present an analysis of either scientific data or detailed vehicle performance.

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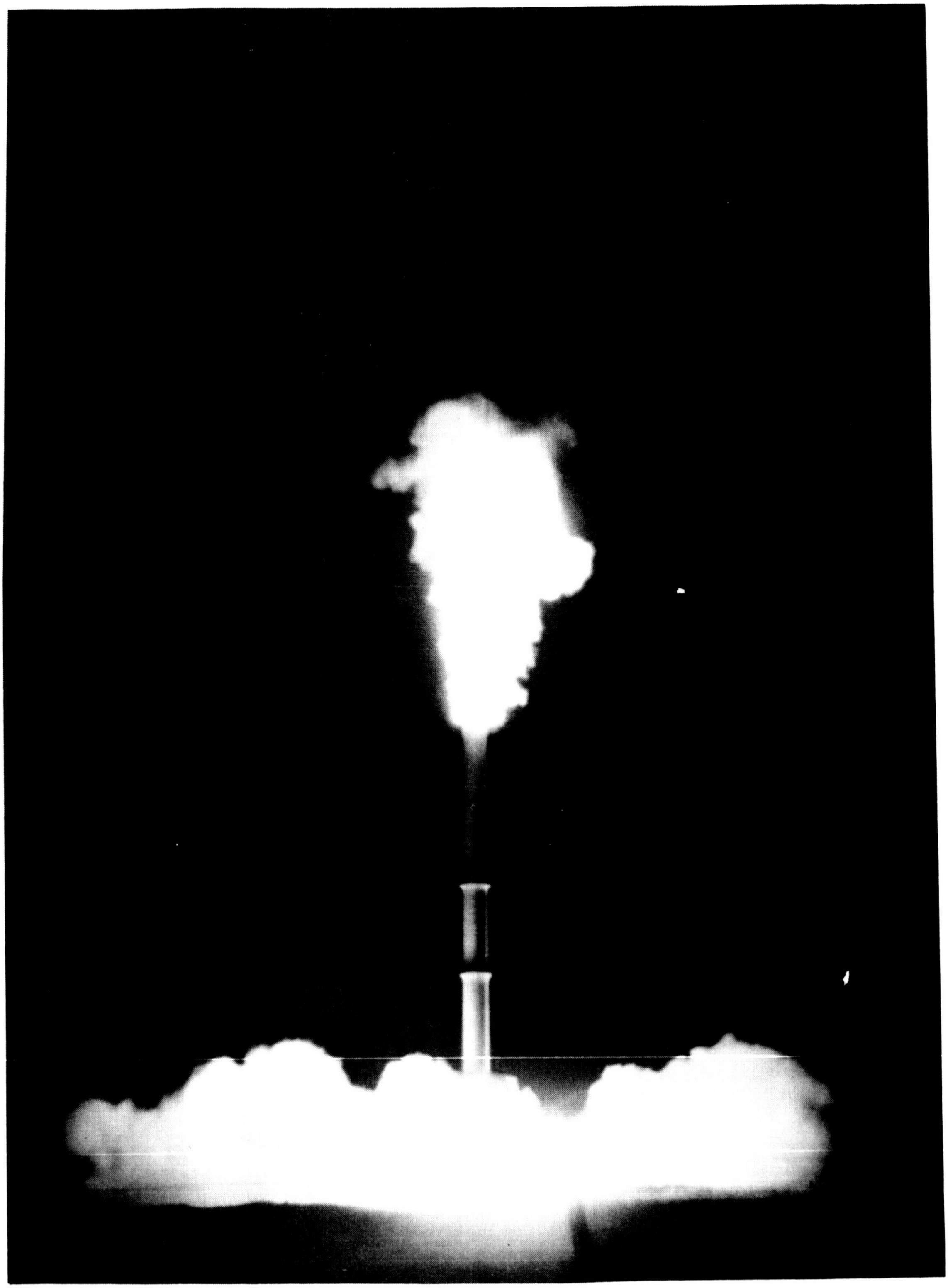


Figure 1. Flight 15.07 GI (KIWI 4) Ignition During Total Eclipse

REPORT ON

UNITED STATES - NEW ZEALAND
SOLAR ECLIPSE PROJECT

By Edward E. Bissell*
U. S. Project Manager

INTRODUCTION

In a joint United States - New Zealand operation, a series of NASA Boosted Arcas sounding rockets were launched from North New Zealand during the total solar eclipse which occurred in the South Pacific area on 30 May 1965. Scientific objectives of these flights were to obtain information on the electron and ion density distribution in the ionospheric D-region by means of radio propagation and DC probe experiments. All data from the nonrecoverable rocketborne payloads were obtained by telemetry to a ground station.

In addition, the New Zealand University of Canterbury, using ground based pulsing techniques, conducted a differential absorption experiment to measure electron concentrations in the same ionospheric region. A secondary experimental objective, therefore, was to compare the respective methods of measuring electron densities.

This eclipse was of particular interest in that its occurrence near dawn, when the sun was just slightly above the horizon, provided a situation wherein the physical

*Head, Sounding Rocket Instrumentation Section processes responsible for the production and maintenance of the lower ionosphere, i. e., below 90 km, were considerably simplified. In this situation, the normal ionizing radiations from the sun cannot penetrate much below 90 km, leaving only cosmic rays as the responsible ionizing agent. At night, when the sun is absent, the ionization takes the form of positive and negative ions. At dawn, however, the atmosphere is exposed to ultraviolet visible sunlight which is not itself energetic enough to directly ionize the neutral gas molecules but which does detach electrons from negative ions. The eclipse, then, provides a situation in which the detachment process can be studied over a drawn-out time interval or compared with an everyday type of sunrise. Figure 1 illustrates Flight 15.07 GI (Range Number KIWI 4) ignition at the moment of total eclipse.

GENERAL

In June 1964 the Planetary Ionospheres Branch of GSFC undertook an expansion and acceleration of the D-region (50 to 90 km) program. The Nike-Apache vehicle which was being used on this program made such expansion prohibitively expensive. A relatively inexpensive meteorological sounding rocket, the single-stage solid-propellant Arcas, had been performing well in its primary role. However, performance of this rocket would be marginal if adapted to carry heavier scientific probes to the D-region. The Boosted Arcas was developed by the Atlantic Research

Corporation to increase both payload weight and altitude capability. As finally developed, the Boosted Arcas had a capability to carry a 10-pound payload to a peak altitude of 85 kilometers.

This rocket, with a newly developed miniaturized D-region payload, was successfully flight tested on NASA Arcas Flights 15.01 GI and 15.02 GI. These flights were included in the joint NASA/GSFC Norway operations of March 1965. Upon the successful operation of rocket and payload, the Sounding Rocket Instrumentation Section (SRIS) and the Planetary Ionospheres Branch combined efforts to prepare D-region payloads and support equipment for the joint U.S. - N.Z. May 1965 Solar Eclipse Project.

The primary purpose of this report is to discuss the operational aspects of the Solar Eclipse Project. However, the merits of the Boosted Arcas sounding rocket system, coupled with recent technological advances in payload miniaturization, may well inaugurate its extensive use in other experiment applications. Project logistical information, telemetry system data, and ground support equipment have therefore been documented for the assistance of project scientists and experimenters desirous of adapting the system to their particular requirements.

PROJECT REQUIREMENTS AND RESPONSIBILITIES

Dr. H.L. Dryden, representing NASA Headquarters, and Dr. J.F. Fleming, representing the National Space Research Committee of the Royal Society of New Zealand, signed a joint Memorandum of Understanding which defined general project requirements and delineated areas of responsibility. The memo, dated 29 April 1965, is reproduced in part as follows:

> The National Space Research Committee of the Royal Society of New Zealand (Space Committee) and the United States National Aeronautics and Space Administration (NASA) affirm their mutual interest in conducting a cooperative scientific project in space research during the solar eclipse of May 1965.
>
> Accordingly, the Space Committee and NASA agree to cooperate in investigating variations in ionization below 80 km due to changes in the photo-detachment rate of negative ions and above that altitude due to changes in the solar zenith angle and solar ultraviolet and X-ray flux caused by passage of the moon. The experiments will be carried out by launching six Boosted Arcas sounding rockets from a site, in the path of totality, near the northern end of North Island in New Zealand. The rockets are to carry payloads for measurement of variations in electron density by the Faraday rotation technique. At the same time, ground equipment will be used to measure differential absorption in order to obtain background profiles of electron density. Together these measurements will provide a record of variations in the decay of ionospheric particles from shortly before until after the solar eclipse.
>
> Responsibility for the sounding rocket investigations rests primarily in NASA's Goddard Space Flight Center, while responsibility for ground-based measurements will rest in the University of Canterbury at Christchurch, New Zealand.
>
> The Space Committee and NASA agree they will use their best efforts to discharge the following responsibilities:

Space Committee Responsibilities:

1. Provide administrative and liaison services in New Zealand

2. Prepare launch site on the Karikari Peninsula, including: pads (two), poles for antenna (five), power, and installation of New Zealand and U.S. equipment

3. Store, assemble, and launch Boosted Arcas sounding rockets

4. Operate range, including range safety

5. Arrange for required liability insurance

6. Provide differential absorption ground equipment, including: transportation, installation, and operation of equipment

NASA Responsibilities:

1. Provide and transport to New Zealand six Boosted Arcas sounding rockets and six payloads

2. Provide on loan and transport to and from New Zealand one Arcas launcher

3. Continue the loan of a second Arcas launcher already in New Zealand

4. Provide and transport to and from New Zealand one ground support van for payloads

5. Provide staff for handling, assembling, and checking payloads and for the operation of the ground support van

Each agency will bear the cost of discharging its respective responsibilities including travel by its personnel and the transportation of the equipment which is its responsibility. No exchange of funds between the Space Committee and NASA is contemplated.

Each agency will designate a project manager to assure proper coordination with the other.

Each agency will be responsible for the reduction and analysis of the data obtained by their equipment and this data will be exchanged with the other agency as soon as possible. The raw and reduced data will become the common property of both agencies. All published results will appear in the open literature or, along with the reduced data, be made available in other ways to the scientific community within six months after the eclipse.

Figure 2 is a functional staff organization chart showing the NASA/GSFC activities that resolved various administrative problems and contributed specialized services in the preliminary planning stages of the project.

PERSONNEL

Table 1 lists the organizations and respective personnel, together with associated project functions, that participated in the joint U.S. - N.Z. Solar Eclipse Project. Not tabulated are the supply, construction, and maintenance services rendered by various New Zealand civilian and RNZAF personnel. Some of the project participants are included in Figure 3, while the complete project line organization chart is shown in Figure 4.

Table 1. Participating Personnel and Organizations

ORGANIZATION	PERSONNEL	FUNCTION
GSFC Sounding Rocket Branch	E.E. Bissell	U.S. Project Manager
	J.C. Modlin	Instrumentation Engineer
	C. Watkins	Ground Station Technician
	C.M. Hendricks	Arcas Vehicle Manager

Table 1. Participating Personnel and Organizations (Cont.)

ORGANIZATION	PERSONNEL	FUNCTION
GSFC Planetary Ionosphere Branch	Dr. A.C. Aiken	Project Scientist
	Dr. J.A. Kane	Project Scientist
	J. Haynes	Instrumentation Engineer
	W. Haynes	Instrumentation Engineer
University of Canterbury	Dr. J.R. Gregory	New Zealand Project Manager
	Dr. A. Ross	
	G. Fraser	
	A.W. Black	
	D.G. Innes	
Royal New Zealand Air Force (RNZAF)	Grp. Capt. R.K. Walker	Commanding Officer, Hobsonville
	Sqd. Ldr. J. Borlase	Launch Officer
	Flt. Lt. B. Whitehead	Assistant Launch Officer
	Flt. Lt. G. Hitch	Range Safety Officer
	Sqd. Ldr. Parker	OC Administrative Wing
	Sqd. Ldr. S. Hill	Chief Technical Officer

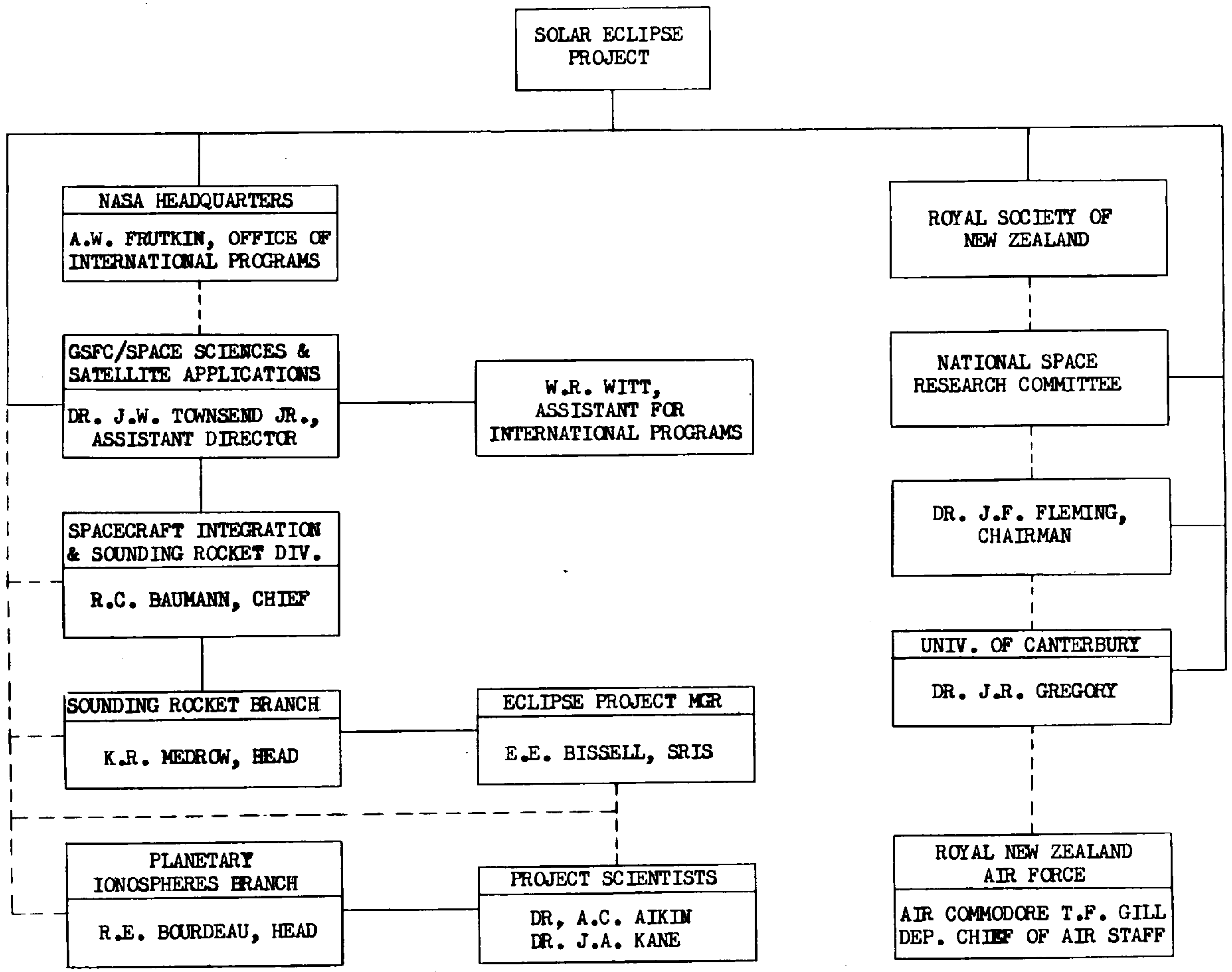
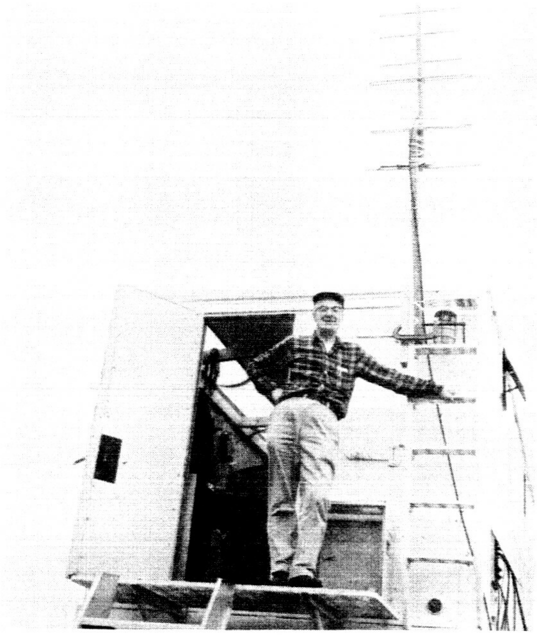
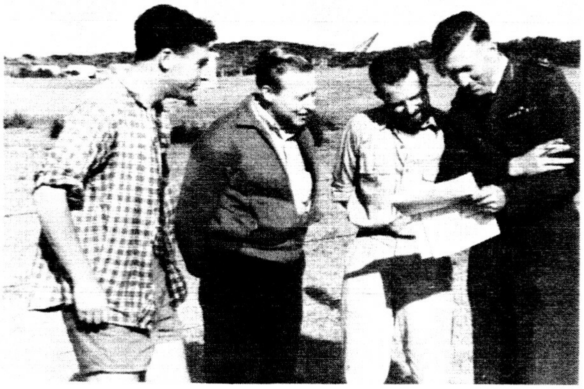
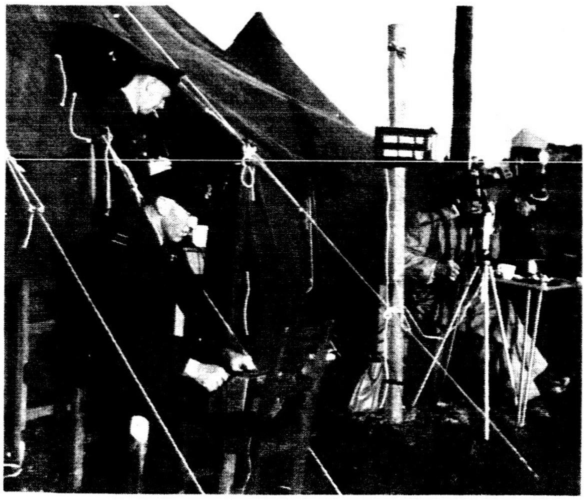


Figure 2. Project Functional Staff Organization Chart





Left. E.E. Bissell (U.S. Project Manager).
Top. D.G. Innez (Univ of Canterbury),
J. Haines (GSFC),
A.W. Black (Univ of Canterbury).



Right. Dr. J.R. Gregory (N.Z. Project Manager).
Top. RNZAF Launch Control Team.

Figure 3. Project Personnel

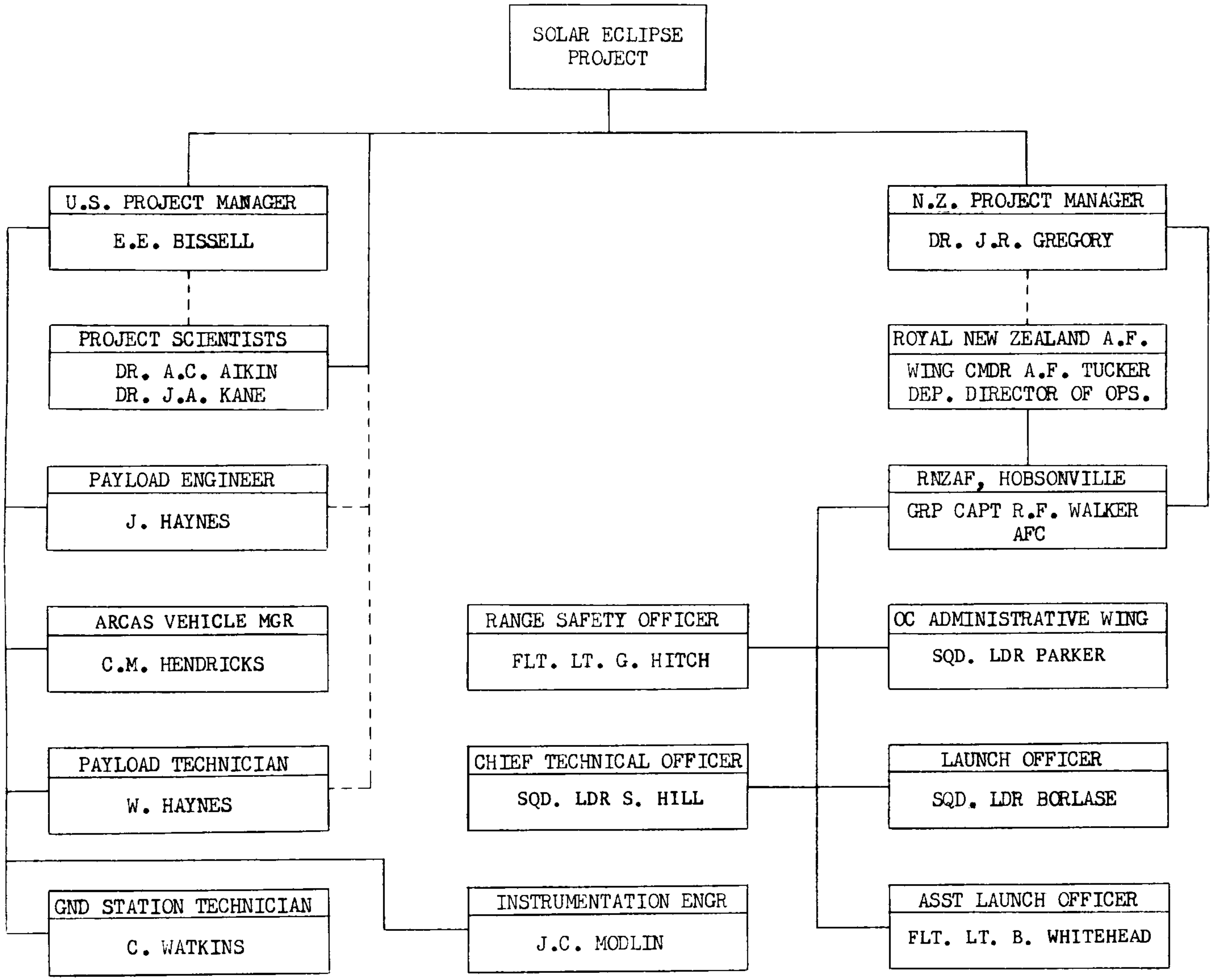


Figure 4. Project Line Organization Chart

PROJECT SCHEDULING

Table 2 is an abstract of the master schedule which served as a control mechanism to ensure successful project completion. Since advance planning was vital to the project, cumulative and programmed performance were compared daily in terms of due date and percentage of work completed. Corrective control action could then be immediately taken and the project accomplished with a minimum of rescheduling.

Table 2. Project Schedule

DATE*	EVENT
20 April 65	Ground station operational.
21 April	Telemetry ground checks and adjustments.
22 April	Mate telemetry and experiment sections.
23-28 April	Payload integration tests.
29 April	Test and evaluation environmental checks completed.
29 April	Complete inventory and loading of equipment.
2-3 May	Ship equipment to Wallops Island and load aboard aircraft.
3 May	Equipment airlift to New Zealand.
3 May	First RNZAF and U. of Canterbury personnel arrive at site.
9 May	First GSFC personnel arrive at site.
12 May	Ground station in place.

Table 2. Project Schedule (Cont.)

DATE*	EVENT
13 May	Launch pads completed.
14 May	Payloads and project scientists arrive at site.
17 May	Antenna supports erected.
23 May	Rockets delivered from storage at Hobsonville.
23-25 May	Prepare rockets and conduct final equipment checks.
26 May	First test rocket fired.
28 May	Second test rocket fired (if necessary).
31 May	Solar eclipse launchings.

*Dates after 3 May are New Zealand time.

SITE DETERMINATION

New Zealand was selected as the launch site because it was the only land that lay along the solar eclipse path of totality and where the eclipse occurred at sunrise. In addition, a group of scientists in that country was engaged in a study of lower ionosphere electron density. The specific launch site near Cape Karikari was selected by the University of Canterbury and approved by NASA/GSFC.

Located at Matai Bay about three miles southeast of Cape Karikari (see Figure 5), the site offered a coastal range having logistical advantages such as access roads, favorable terrain features, and proximity to Kaitaia where construction equipment was available. The natural shelter

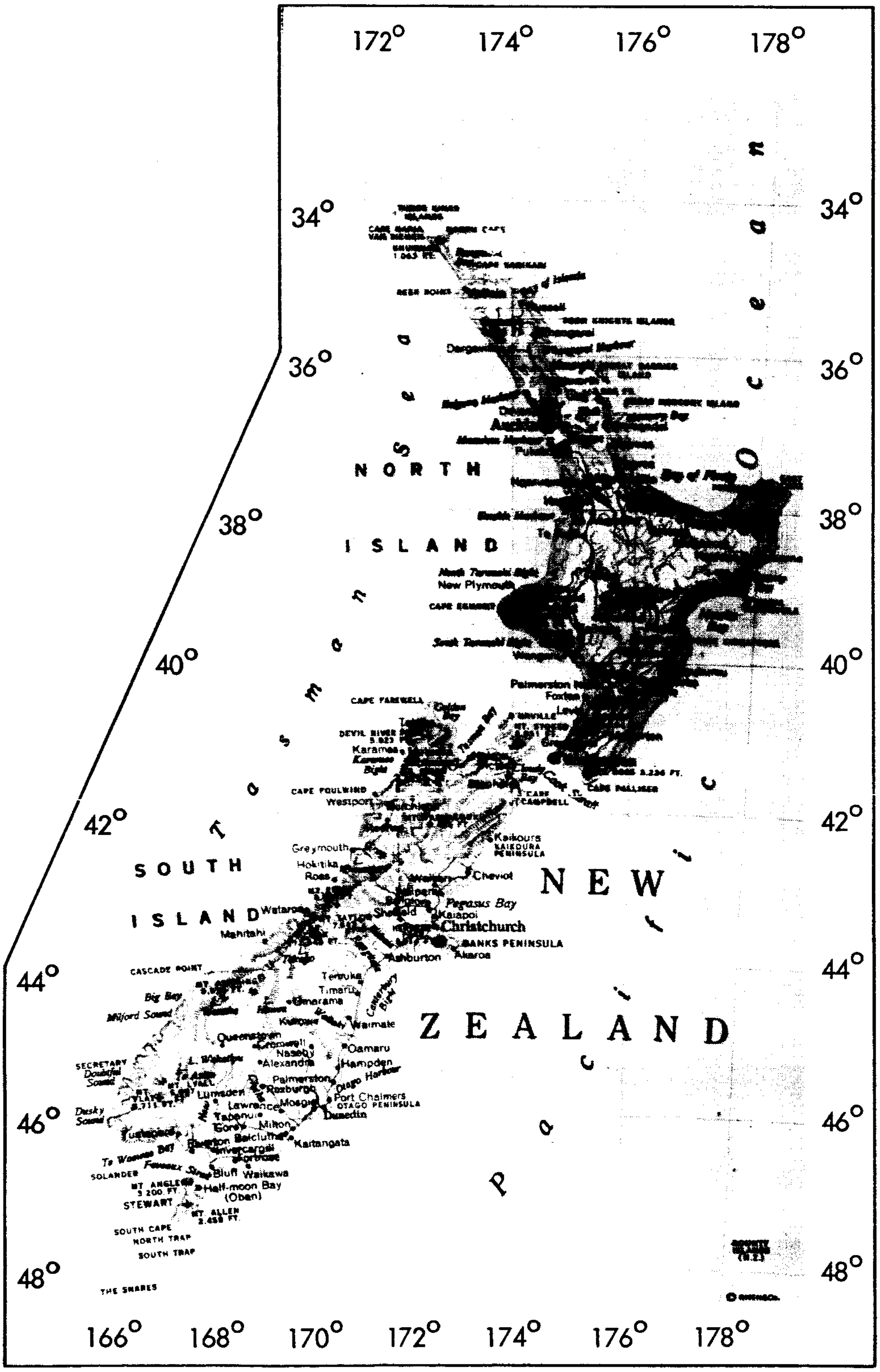


Figure 5. Map of New Zealand

afforded by the bay location and generally favorable weather conditions, i. e., temperature range 40° to 60° F, average winds below 25 knots, and light precipitation, were deciding factors. While the site was close to the northern limit of the 85-mile wide path of totality, the reduction in eclipse coverage was deemed negligible since the rockets would be launched into the path of the eclipse.

LOGISTICAL INFORMATION

Equipment shipped to the site included reserves to cover unforeseen needs in addition to that anticipated for normal replacement. Various types of power and radio frequency cable were supplied to support the University of Canterbury experiment. In addition, a deflector plate assembly for use with the Boosted Arcas was supplied to modify the Arcas launcher which had been previously loaned to New Zealand.

SHIPPING DATA

Table 3 lists crated shipping data for GSFC supplied equipment. The trailer which housed the ground station equipment was also packed with maintenance tools, spare parts, and other associated equipment (refer to Table A-1 and A-2, Appendix A). Rockets, boosters, and ignitors were packaged separately, with spare ignitors for a rocket and booster also included. Payload and nose cone assemblies were not included in this shipment as they were shipped later with project personnel. Equipment was shipped via a C-124 MATS (Military Air Transport Service) aircraft (Table A-3, Appendix A).

Table 3. Equipment Shipping Data

ITEM NO.	QTY	DESCRIPTION	WEIGHT (Lb)	VOLUME (CuFt)	DIMENSIONS (In)
1	1	Ground Station Trailer[a]	23 670	1492.5	199x96x135
2	1	Arcas Closed Breech Launcher: Shipped in three boxes containing launcher component parts,	1225	126.9	53x53x78
		maintenance and installation tools, and	425	95.9	102x65x25
		spare parts	140	10.0	86x12x16
3	2	Deflector Plates	72	3.5	20x20x15
4	7	Rocket Motors (w/ eight ignitors)[b]	1085	70.0	76x15x15
5	7	Interstage and Boosters (w/eight ignitors)[c]	560	46.9	51x15x15
		Totals	27 177	1845.7	

[a]Trailer also served as shipping container for other equipment; refer to Appendix A.

[b]Explosive weight 455 pounds.

[c]Explosive weight 245 pounds.

TRANSPORTATION

All equipment was transported via air as shipment by water was not feasible due to the time element involved. Various factors made it mandatory to ship such relatively large amounts of equipment by air, namely: lead time required for equipment installation, operation, and final checkout; the necessity of conducting a successful test launching in Norway prior to shipment of equipment to New Zealand; and, finally, the scientific aims of the entire mission would be negated if the New Zealand launchings were not conducted on schedule.

Cargo airlift was by a United States Air Force MATS-supplied C-124 aircraft, which departed Wallops Island, Virginia, on 3 May and arrived at Whenuapai Airfield in Auckland, New Zealand, on 8 May. (Surface transportation would have taken a minimum of 60 days.) All equipment was then hauled by common carrier over main highway to Kaitaia some 200 miles distant. The last 30 miles from Kaitaia to the launch site was over paved roads and at times, and for short distances, over unimproved roads. Figure 6 shows the type of terrain and equipment movement near the site.

RANGE REQUIREMENTS

The launch site was located on Matai Bay about three miles southeast of Cape Karikari at longitude 173° 24' 19" East and latitude 34° 49' 30" South. A 60° sector, from 002° to 062° true, extending 50 miles seaward served as the impact area. The range danger area was defined as being within a one statute mile radius of the launch pads, while the local danger area was encompassed within a 200-yard radius of the pads. Exact range parameters are delineated in Figure 7.

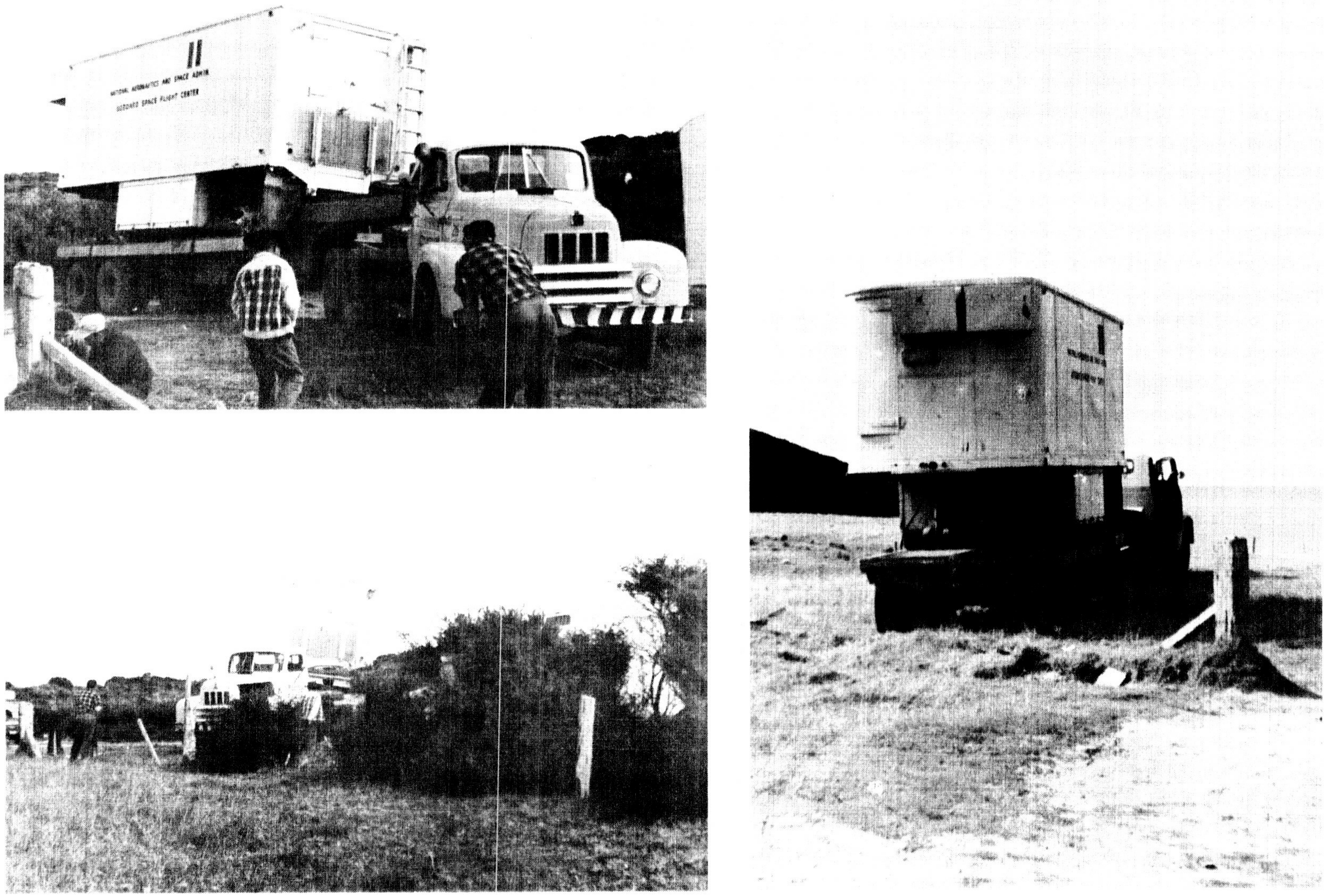


Figure 6. Transportation and Terrain Features

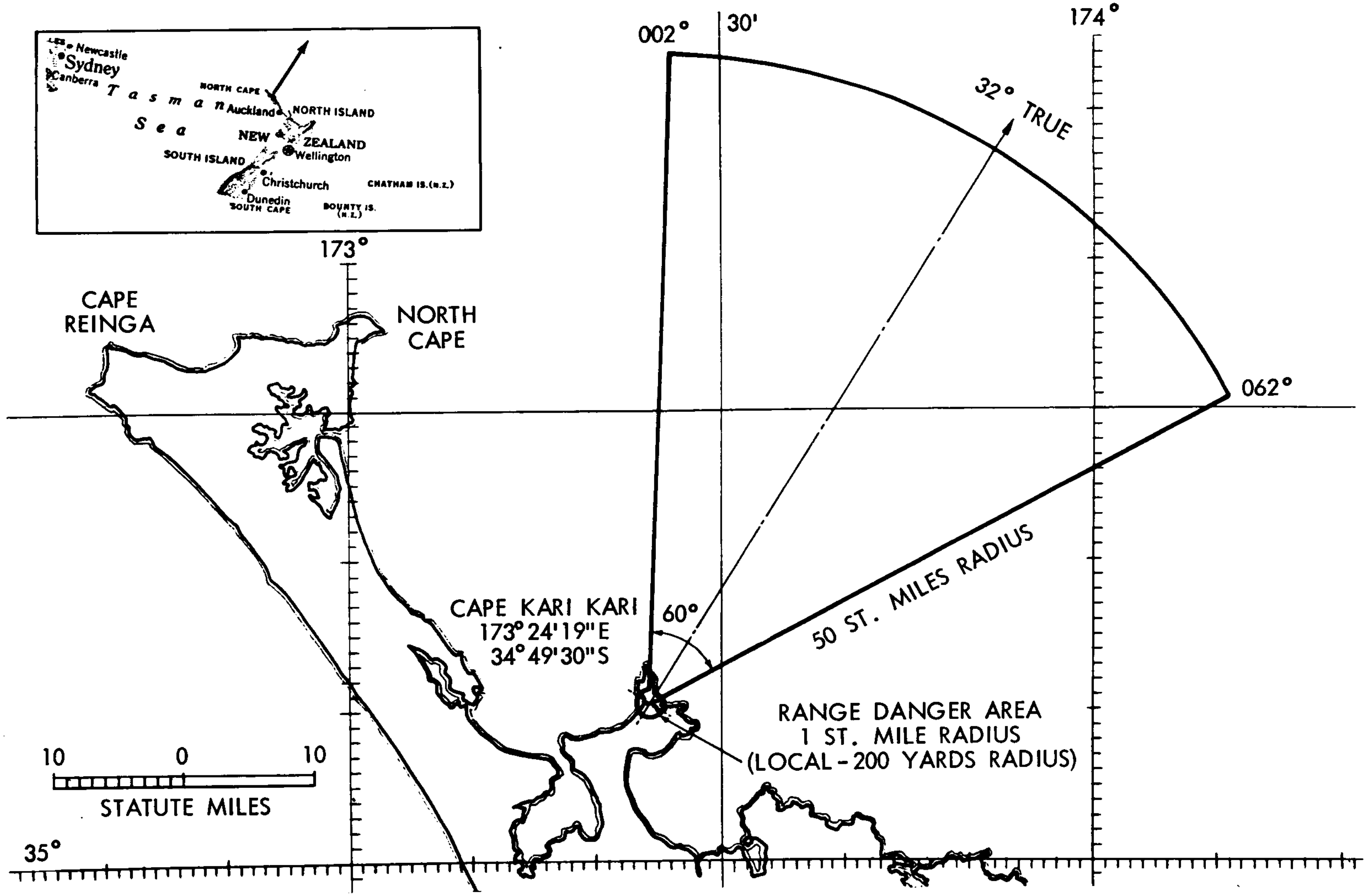


Figure 7. Range Requirements

COMMUNICATIONS

Figure 8 shows the various main lines of communications, the majority of which were supplied and maintained by the RNZAF. NASA/GSFC supplied seven transceivers which were used extensively during payload testing and to back up the communication system.

POWER REQUIREMENTS

A RNZAF supplied and operated motor generator (see Figure 9) furnished power to the GSFC ground station. Power supplied, as is customary in New Zealand, was 416 volt, 50 cycle, 4-wire three-phase WYE connected with a nominal 230/240 volts from each phase to neutral. A Westinghouse 50 cps type DT-3 transformer, provided by GSFC, was employed to step down the power to the U.S. standard 110-220 volts required for ground station operation. To ensure continuous operation, the RNZAF also supplied a standby generator.

WIND WEIGHTING

Preliminary launcher settings are necessarily affected by range safety considerations and physical boundaries. Since the New Zealand launchings were to seaward, these problems were minimized. However, in order for the rocket to achieve maximum apogee consistent with range safety, launcher azimuth and elevation angles must be amended by the introduction of wind weighting factors. Meteorological data including wind direction and velocity to 7000 feet were supplied by the University of Canterbury and RNZAF personnel (see Figure 9).

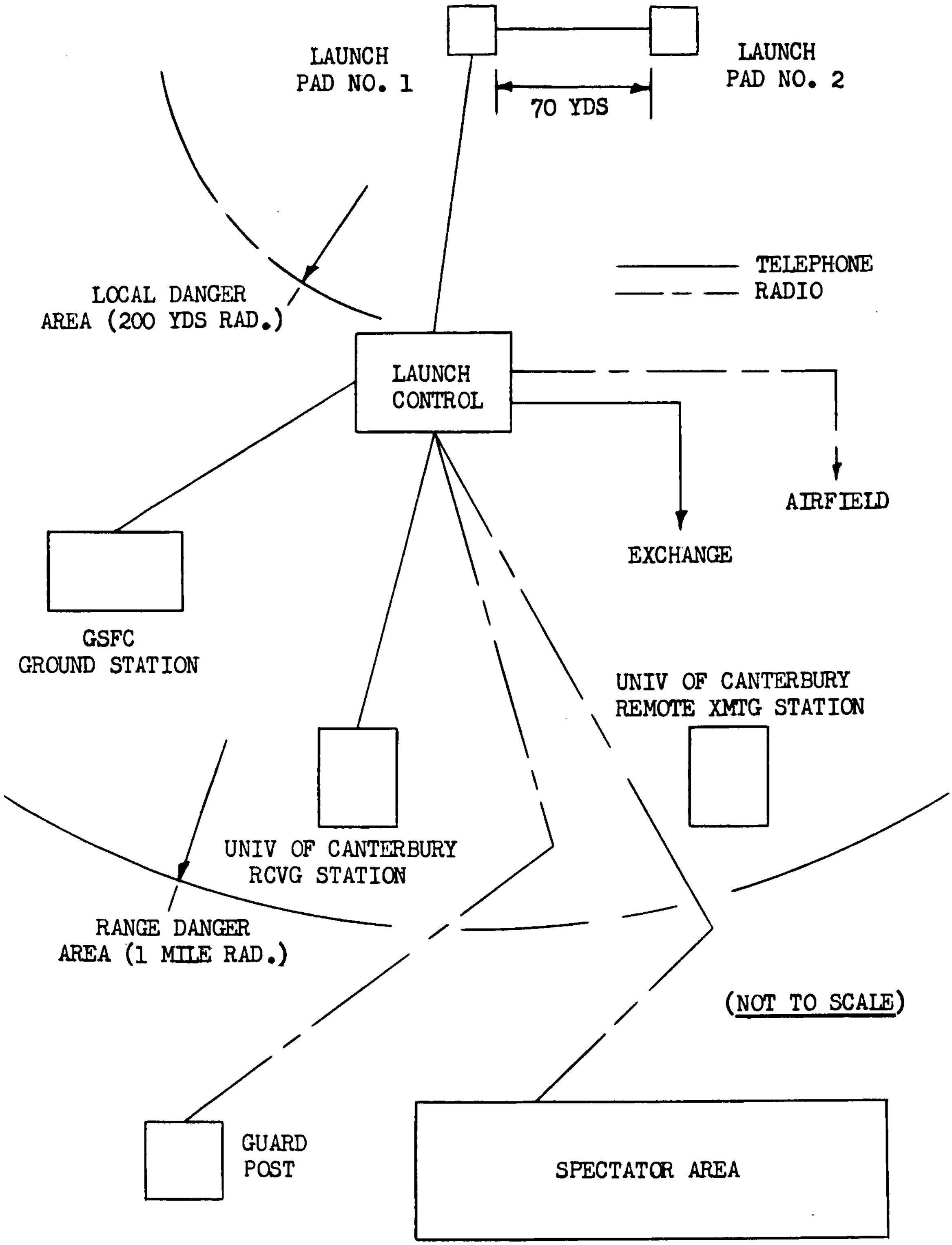


Figure 8. General Communications Layout

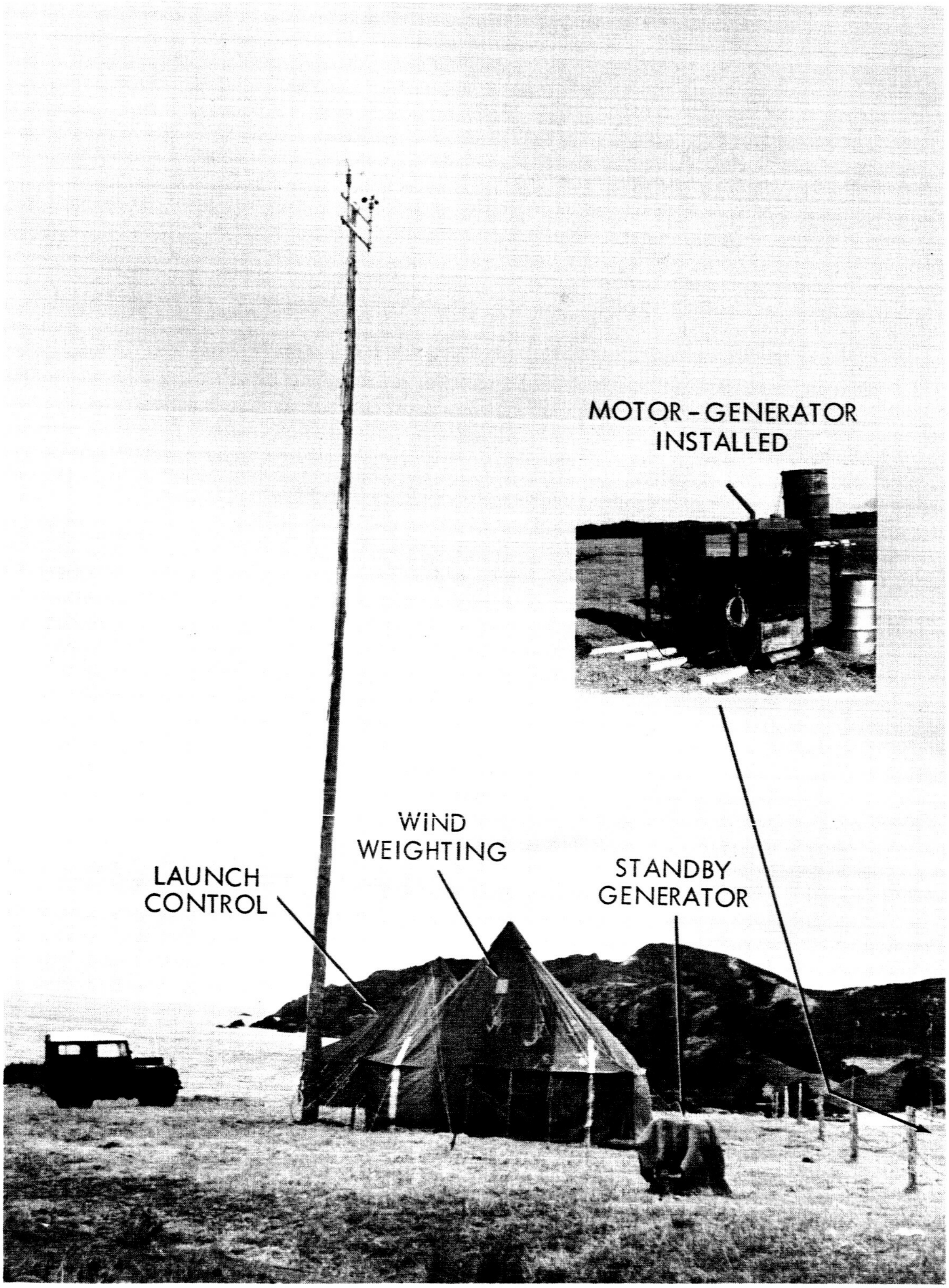


Figure 9. Wind Weighting and Power Generating Facility

Prevailing winds were continuously monitored and necessary adjustments, when required, were made to launcher settings prior to each firing.

FREQUENCY MONITORING

While the 240.2 mc telemetry and 2404 and 3360 kc radio propagation experiment frequencies were approved by New Zealand authorities, there could be no assurance that the assigned frequencies were free of interference from foreign transmissions. Past experience has shown that ground-based monitoring stations have, at times, been unable to detect such interference. Consequently, the RNZAF supplied a Canberra aircraft which overflew the launch site at an altitude of 40 000 feet to monitor the experiment frequencies for CW and voice.

The flight was conducted at early dawn prior to the KIWI 1 launch. While 2404 kc was completely clear, there was slight unidentifiable splatter from a distant foreign broadcast station on 3360 kc. (The line of sight telemetry frequency did not require monitoring.) It was decided, and later confirmed, that the faint interference detected would not adversely affect the scientific aims of the experiment.

DISSEMINATION OF PUBLIC INFORMATION

Public interest in the project had been stimulated well in advance through statements released to the local press by the New Zealand Space Research Committee. This one fact alone probably contributed materially to the excellent New

Zealand public response, and was especially valuable in obtaining access through private property and procuring local support services.

Once the launch site was established, every opportunity consistent with range safety was afforded the New Zealand public and local newspaper reporters to ask questions and inspect the equipment. The Arcas security declassification in early March 1965 had removed the greatest barrier to public information. A spectator area, established some 1.5 miles from the site, resulted in several hundred people viewing the rocket launchings. This was considerably more than had traveled the long distance to observe the practice launch five days earlier. In both instances the facility was opened to the public immediately after the firing and full explanations offered as to what had transpired. The wide press, radio, and television coverage given the project in New Zealand should broaden public interest in space exploration programs.

BOOSTED ARCAS LAUNCHER AND ROCKET SYSTEM

For the past few years there has existed the requirement by Goddard's Planetary Ionospheres Branch for a simple rocket system that would carry a 15- to 20- pound payload to 90 km. Due to recent advances in payload miniaturization and resultant weight reduction, it was found that in some instances the Nike-Apache vehicle was being used to launch payload weights that were substantially beneath design capability. In addition, the complex launch site required for Nike-Apache restricted the areas from which launchings could be undertaken.

BOOSTED ARCAS

The single-stage Arcas was originally developed as a solid-propellant sounding rocket designed to carry a 10-pound payload to an altitude of about 65 kilometers. Thus severely limited, the vehicle performed yeoman's service chiefly as a meteorological support rocket designated Arcasonde. Even in this capacity, however, the unboosted vehicle displayed a marked tendency to underperform. To remedy this deficiency and increase peak altitude capability, the Atlantic Research Corporation (ARC) proceeded to develop the Boosted Arcas.

Design Description

The Boosted Arcas (refer to Figure 10) is a two-stage vehicle which consists of a standard Arcas rocket or sustainer, a booster, and interstage coupling. Both stages are powered by a solid propellant, the Arcas sustainer by an end-burning plastisol (Arcite 373D) type and the booster by a six-point internal burning grain. Separate ignition systems are employed; however, ignition of both stages is nearly simultaneous as a g-switch in the sustainer firing line closes the Arcas firing circuit after initial booster motion.

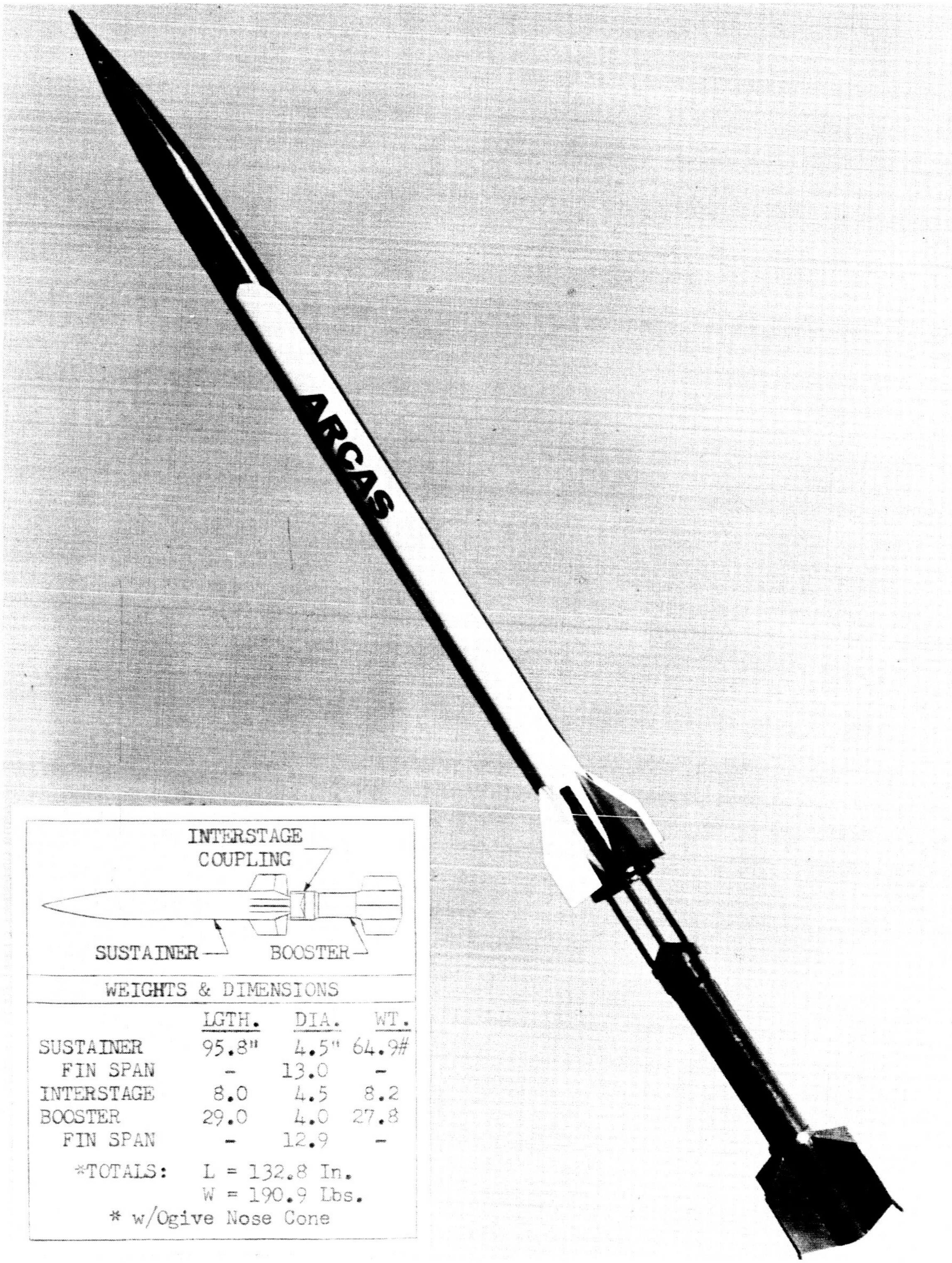


Figure 10. Boosted Arcas Rocket

Essential weights and dimensions are as shown in the Figure 10 insert. Length of the Arcas sustainer will naturally vary with the type of nose cone used; the 95.8-inch length shown is with the ARC No. 8 ogive phenolic plastic nose cone. The base of the 8.2-pound interstage coupling is a deflection cone which threads onto the booster head, while the sustainer seats on an aluminum ring located near the top of the coupling. Two notches, 180 degrees apart and centered between the two fins, are cut into the sustainer aft flange to accommodate location pins on the aluminum ring and thereby prevent sustainer rotational movement.

Performance Characteristics

With an effective launch elevation angle of 85 degrees, and launched from a sea level site, the Boosted Arcas will normally reach a peak altitude of approximately 85 kilometers with a 10-pound payload. At launch, booster and sustainer ignition occur practically simultaneously. The booster and interstage coupling assembly falls away after 1.5 seconds. Sustainer burnout occurs at T+29.5 seconds, after which time a coast phase is assumed to peak at T+146 seconds; impact occurs at T+294 seconds.

The sustainer and booster stabilizing fins are factory installed and canted 0.945 degrees and 1.25 degrees, respectively. These settings provide a roll rate of about 25 rps at sustainer burnout. Normal range from launch to impact is approximately 28.5 statute miles.

LAUNCHER

The Boosted Arcas sounding rocket system is launched by a standard ARC EX 120 launcher modified by replacement of the breech door with a deflector plate assembly.

Design Description

Launcher No. 2, as installed during the New Zealand Solar Eclipse Project, is shown in Figure 11. Major components (see Figure 11 insert) are a 16.6-foot long launch tube, azimuth table and base assembly, and a free volume cylinder. The launch tube, 13.5 inches in outside diameter, consists of three flanged sections bolted together. Gaskets are installed between each flange to prevent gas leakage. Tube inside diameter is 13.2 inches.

The free volume cylinder functions as a pressure vessel to retain rocket booster exhaust gases generated during ignition and combustion. An access opening in the cylinder base serves as the breech; however, the hinged breech plate supplied with the launcher must be replaced with a deflector plate assembly when firing the Boosted Arcas. When so modified, booster and sustainer ignition lead wires must be routed through the plate to the individual ignitors. Mounting of the cylinder, 37.8 inches high and 30 inches in diameter, is through bearings to allow vertical rotation.

Launcher rotation in the horizontal plane is provided by the azimuth table assembly, which also functions to support the cylinder and launch tube. Six lugs are provided

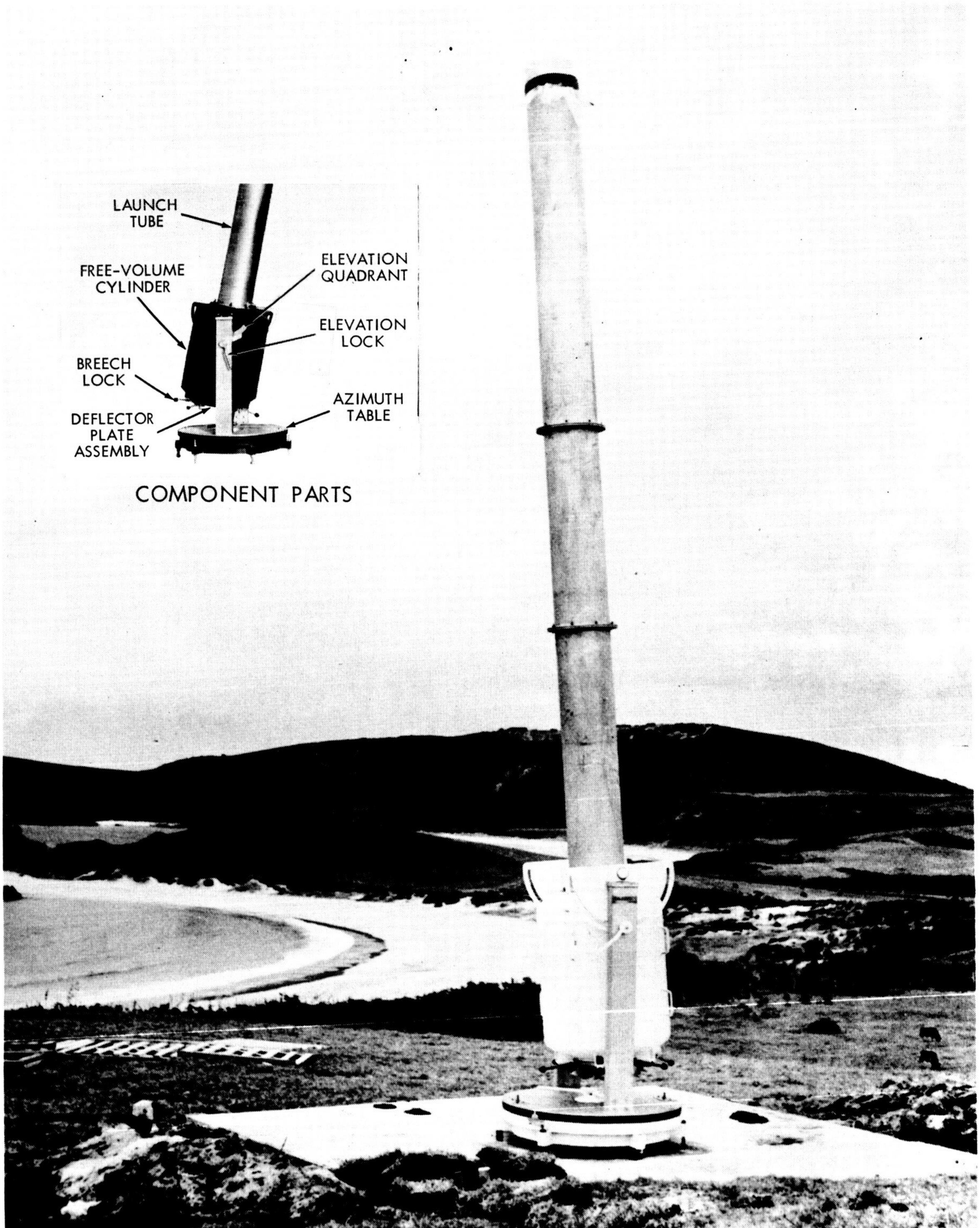


Figure 11. Launcher No. 2 Component Parts

on the table base, three for anchoring to a concrete pad and three for leveling. Maximum height of the launcher is 21.5 feet; total weight is 500 pounds.

Operation

Graduated scales are provided on the azimuth table and elevation quadrant to permit direct reading of azimuth and elevation settings. Launch position is adjustable through 360 degrees in the horizontal plane, while vertical plane adjustments through 90 degrees are possible. However, normal recommended vertical launch angle is 80 to 85 degrees. Elevation and azimuth locks are provided to secure the launch tube after it has been manually set.

Loading operations include the installation of four plastic spacers to support and center the rocket in the launch tube. After booster and sustainer ignition, the released exhaust gases are entrapped by the free volume cylinder. The pressure buildup exerts the necessary force to accelerate rocket and booster along the launch tube. After emerging from the launch tube the plastic spacers fall away, usually in fragments.

PAYLOAD

Figure 12 illustrates the typical Arcas rocket (less booster) as launched during the U.S. - N.Z. Solar Eclipse Project. Both experiment and telemetry sections were contained in an aluminum 4.5-inch diameter cylindrical housing

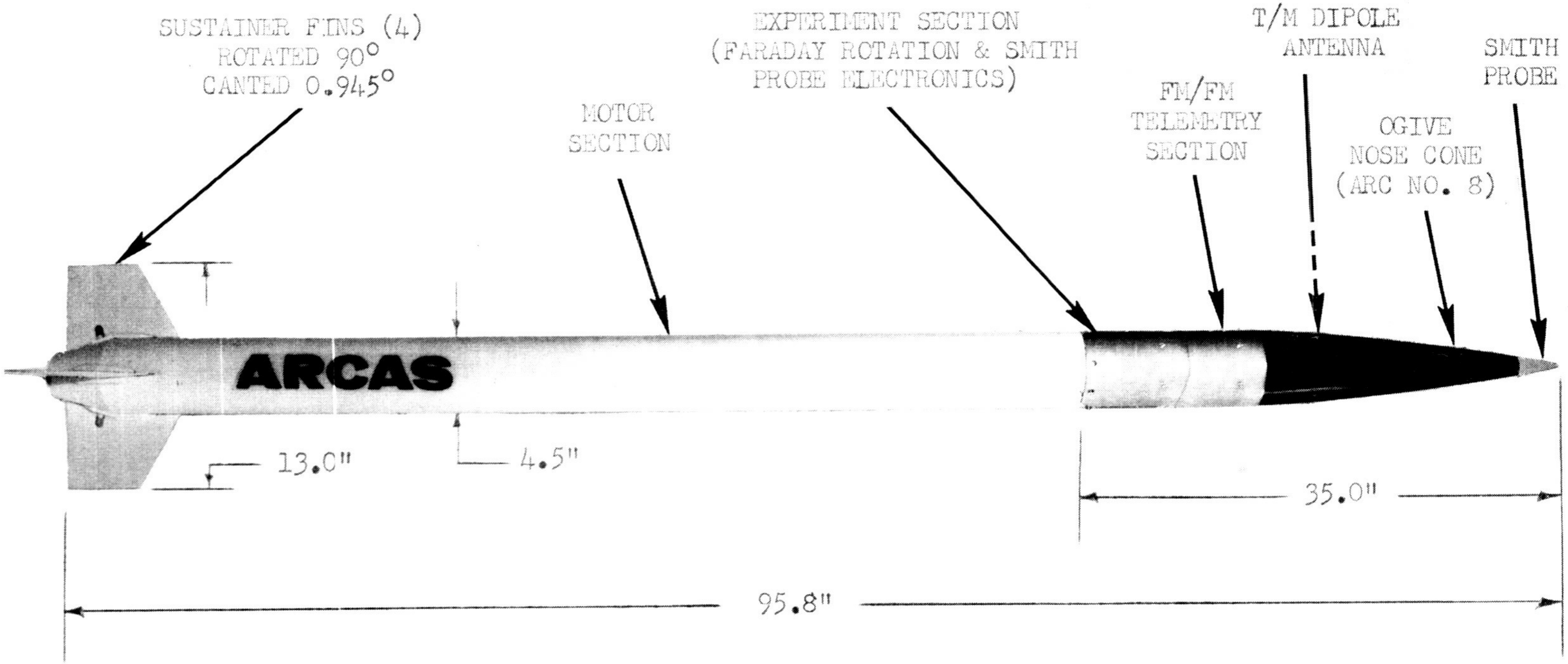


Figure 12. Typical New Zealand Arcas General Arrangement

and weighed approximately 12 pounds. The telemetry antennas were enclosed in a standard ARC No. 8 ogive phenolic plastic nose cone which was modified to accept a tip-mounted DC electron probe.

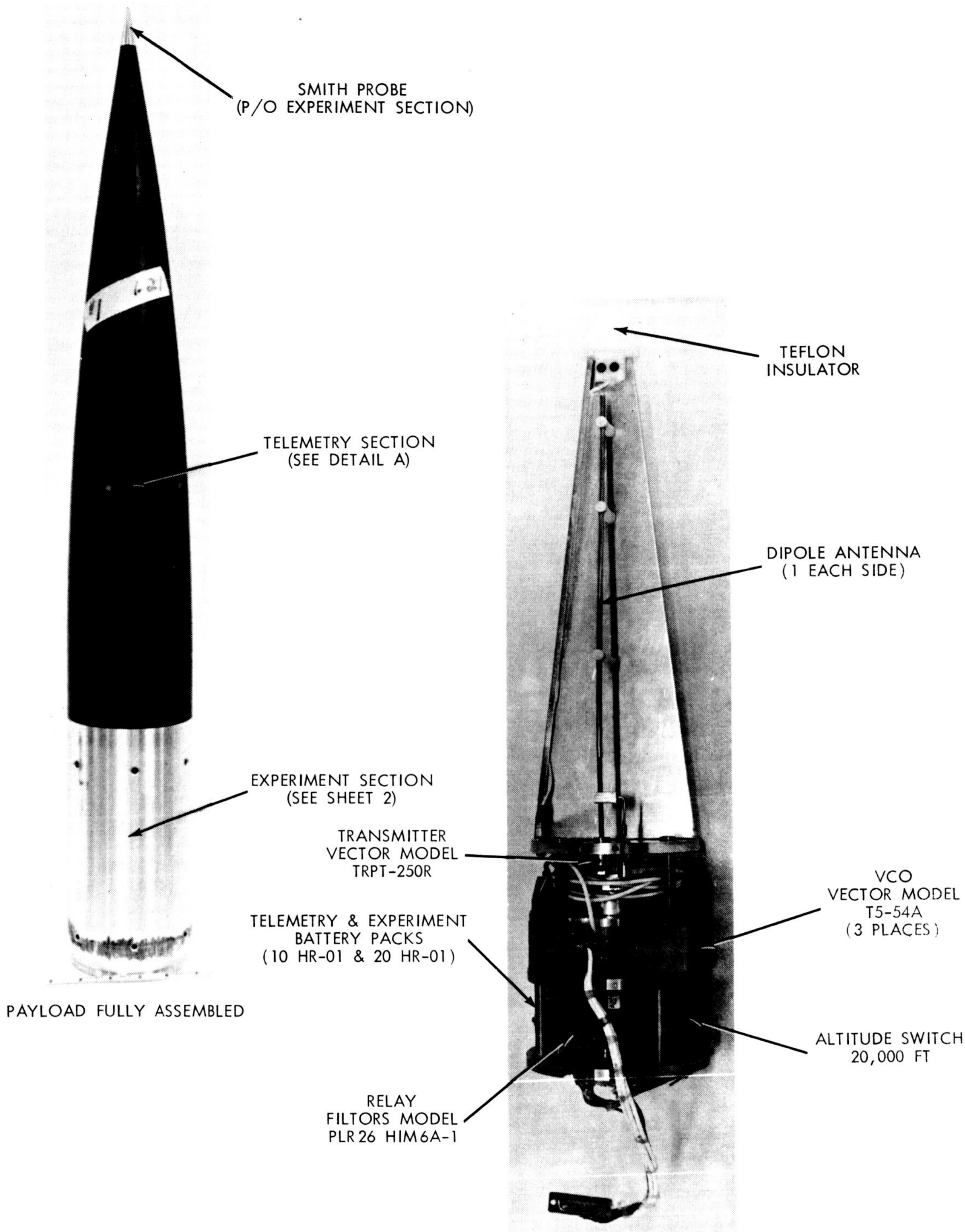
EXPERIMENT SECTION

Information concerning electron and ion density distribution in the ionospheric D-region was obtained by two distinct methods: a radio propagation (or Faraday rotation) experiment and a DC probe experiment. Data derived from the DC probe, while useful in analyzing Faraday rotation results, was not essential to the major experiment goal.

Radio Propagation

Linearly polarized rf signals were transmitted to the rocket from two ground-based Collins Model 367A-3 500-watt CW transmitters operating on 3360 and 2404 kc, respectively. The rocket-borne ferrite rod receiving antennas (Sheet 2, Figure 13), rotated with the rocket, approximately 20 to 25 rps. As the airborne antennas rotated, the linearly polarized patterns of the ground-transmitted signals were crossed, causing the airborne received signals to be modulated at twice the rocket spin rate.

These rf signals were then fed to their respective receivers and the AGC voltages were telemetered to the ground station on 52.5 and 40.0 kc voltage controlled oscillators (VCO). Variations in the telemetry



DETAIL A
PAYLOAD TELEMETRY SECTION

Figure 13. Payload Equipment Installation (Sheet 1 of 2)

EXPERIMENT SECTION B/M		
NO.	ITEM	DESCRIPTION
1	Electrometer	WTA Model 10-10L
2	Batt Pack	Mallory RM625 (19)
3	Cal Resistor	Victorine 10^{11} OHMS
4	Cal Relay	P & B Model SC11-DB
5	Altitude Sw	Leesona Moos 6617A
6	Receiver No. 2	GSFC (3360 KC)
7	Receiver No. 1	GSFC (2404 KC)
8	Relay	Filters PLR26HIM6A-1

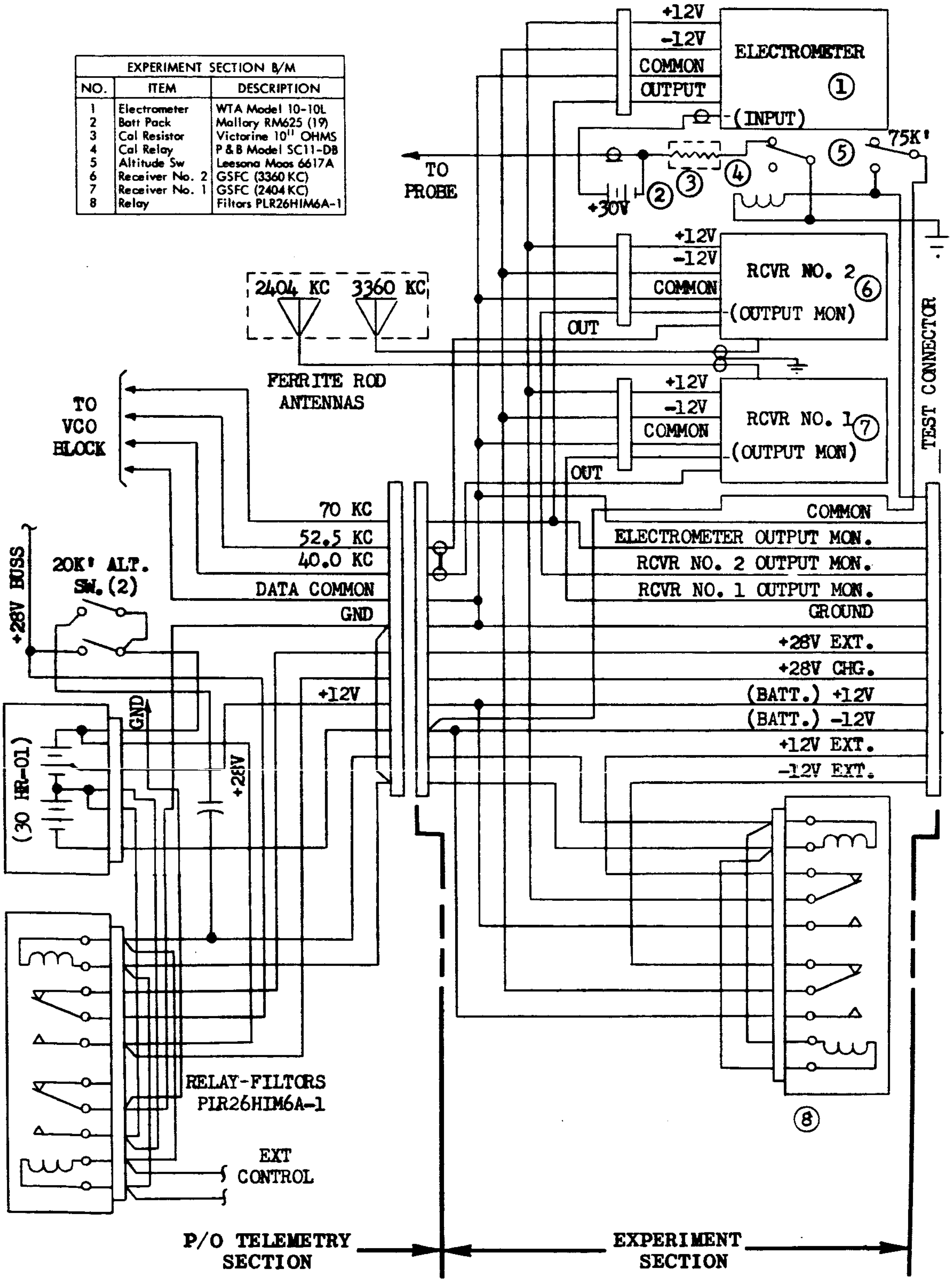


Figure 13. Payload Equipment Installation (Sheet 2 of 2)

rf signal were minimized at the ground station by the circular-polarized helix receiving antennas.

As exhibited by the real time paper record, the frequency of the telemetered data is then the sum of the rocket spin frequency and the ionospheric Faraday rotation frequency. The rocket spin rate was independently determined from the recorded AGC, obtained by using a linearly polarized telemetry antenna. Therefore, a comparison of the two traces indicates the Faraday rotation polarization plane from which electron density profiles may be calculated.*

DC Probe

Ionization charges were measured with a DC probe experiment (often referred to as Smith or Langmuir probe), consisting mainly of an electrometer, a stainless steel probe, and calibration circuitry. Precise circuit calibration was desirable for better data interpretation. Therefore, in addition to ground test provisions, the inflight calibration level was continuously monitored via the telemetry system until an altitude switch opened at 75 000 feet to remove the calibration circuit. The type and magnitude of ions which accumulate on the charged probe may be determined by the resultant voltage drop measured by the electrometer and telemetered to the ground station on a 70 kc

*Further information may be obtained from the following article:

Aiken, A.C.; Kane, J.A.; and Troim, J.: Some Results of Rocket Experiments in the Quiet D Region. J. Geophys. Res., Vol. 69, No. 21, Nov. 1, 1964, pp. 4621 - 4628.

subcarrier frequency. Figure 14, a photograph of the KIWI 6 real time record from T-0.5 through T+3.5 seconds, shows calibration dropout as it appeared on the ground station record.

TELEMETRY SECTION

Various factors such as the nature of data to be telemetered, accuracy and frequency response required, and payload weight and packaging limitations determined the selection of an FM/FM telemeter for use in the Arcas payloads. A 0.25-watt 240.2 mc FM/FM telemetry transmitter (Vector Model TRPT-250R), modulated by three VCO's, was used to transmit radio propagation and DC probe data. Table 4 lists the VCO IRIG bands and data allocations.

Table 4. VCO IRIG Band Parameters

FREQUENCY (kc)*	IRIG BAND	DATA ALLOCATION
70.0	18	Electrometer
52.5	17	3360 kc Faraday Rotation
40.0	16	2404 kc Faraday Rotation

*Maximum deviation ±7.5%

Component Selection

All telemeter components were subminiature transistorized types (in keeping with payload space and weight limitations) which had previously established a record of reliability in other rocket payloads designed by the Sounding Rocket Instrumentation Section. In addition, similar transmitters

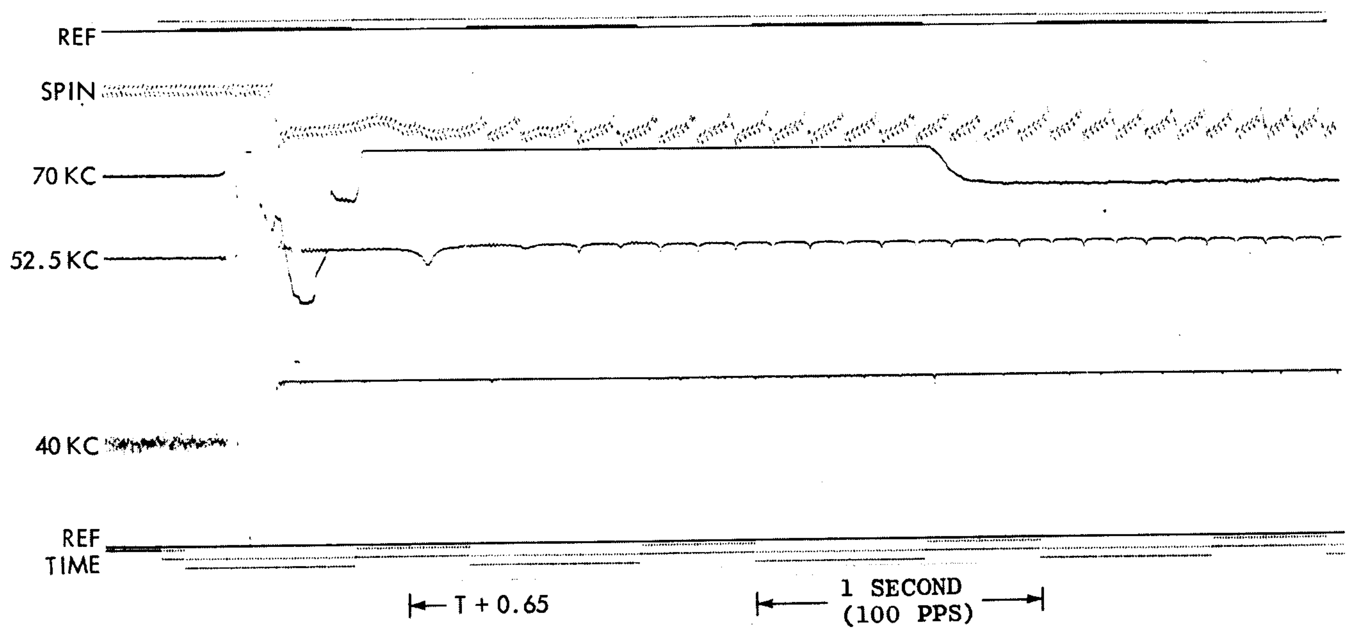


Figure 14. Flight 15.09 GI (KIWI 6) Real Time Record

had performed well in such high stress applications as the Transit navigational satellite and the NASA Orbiting Solar Observatory (OSO) Satellite. Performance parameters of all components were individually checked to ensure proper operation within design tolerances. Table 5 contains a listing of the various components, together with physical and performance specifications.

Table 5. Telemetry Component General Specifications

MIXER AMPLIFIER (VECTOR MODEL TS-58A)	
Size	7/8"D x 1-1/16"W x 1-3/8"H
Weight	1.5 oz.
Input & Output Impedances	10K and 5K ohms max., respectively
Gain	Adjustable to 15X
Stability	Supply voltage variation of ±10% will cause no change in unit gain.
Power Requirements	28V dc at 10 ma
VCO (VECTOR MODEL TS-54A)	
Size	7/8"D x 1-1/16"W x 1-3/8"H
Weight	1.75 oz.
Input & Output Impedances	1 megohm and 47K ohms, respectively
Stability	Supply voltage variation of ±10% will vary center frequency less than ±0.5%
Linearity	Less than ±0.25% of design bandwidth
Modulation Sensitivity	0 to 5V dc for ±7.5% deviation
Power Requirements	28V dc ±10% at 15 ma

Table 5. Telemetry Component General Specifications (Cont.)

TRANSMITTER (VECTOR MODEL TRPT-250R)	
Size	2.6"Dia x 1.5"H
Weight	8 oz.
Input & Output Impedances	5K ohms min. and 50 ohms, respectively
Power Output	0.25 watts nominal
Frequency Range	215 to 260 mc
Power Requirements	28V dc $\pm$10% at 80 ma
RELAY (FILTORS TYPE PLR26HIM6A-1)	
Size	0.400"D x 0.797"W x 0.885"H
Weight	0.8 oz.
Type	DPDT magnetic latching
Latching Time	5 msec max.
Contact Rating	2 amps at 28V dc
ALTITUDE SWITCH (CARMAC TYPE ES4-20)	
Size	1-7/8"D x 1-5/8"W x 11/32"H
Weight	0.64 oz.
Type	SPST barometric (N.O.)
Range	20K' $\pm$2K'; open 500' to 2.5K' below point.
Contact Rating	0.5 amp at 28V dc

Aerodynamic and structural considerations limited telemetry antenna placement to a location inside the nose cone (sheet 1, Figure 13). This position, however, resulted in a highly efficient telemetry transmitting antenna system. The antenna was essentially a dipole consisting of two resonant quarter wave sections, each with provisions for adjustment. Appendix B contains typical radiation patterns for both horizontal (Θ) and vertical (Ø) polarization for a frequency of 240.2 mc measured at $\phi = 30^{\circ}$ intervals. Also included are sample Smith chart plots of antenna impedance characteristics. Note that antenna impedance will vary according to the specific installation; it was essential that each antenna and nose cone be considered a matched assembly.

Functional Operation

A block diagram of the telemetry and instrumentation system used for the Eclipse Project Arcas payloads is shown in Figure 15. Three VCO's generated the subcarrier frequencies which were frequency modulated by the experiment data. Fully transistorized to minimize size and weight, each VCO consisted of an amplifier and multivibrator circuit in addition to an output band pass filter to suppress spurious harmonics generated by the multivibrator.

Adding and amplification of the VCO output signals were accomplished by the mixer amplifier, also a subminiature transistorized unit. The output of the mixer amplifier was applied to a solid state transmitter consisting of a crystal controlled oscillator, a phase modulator, four frequency multiplier stages (three tripler and one doubler), and a final output power amplifier stage. Transmitter rated nominal rf power output was 0.25 watt into an impedance of 50 ohms.

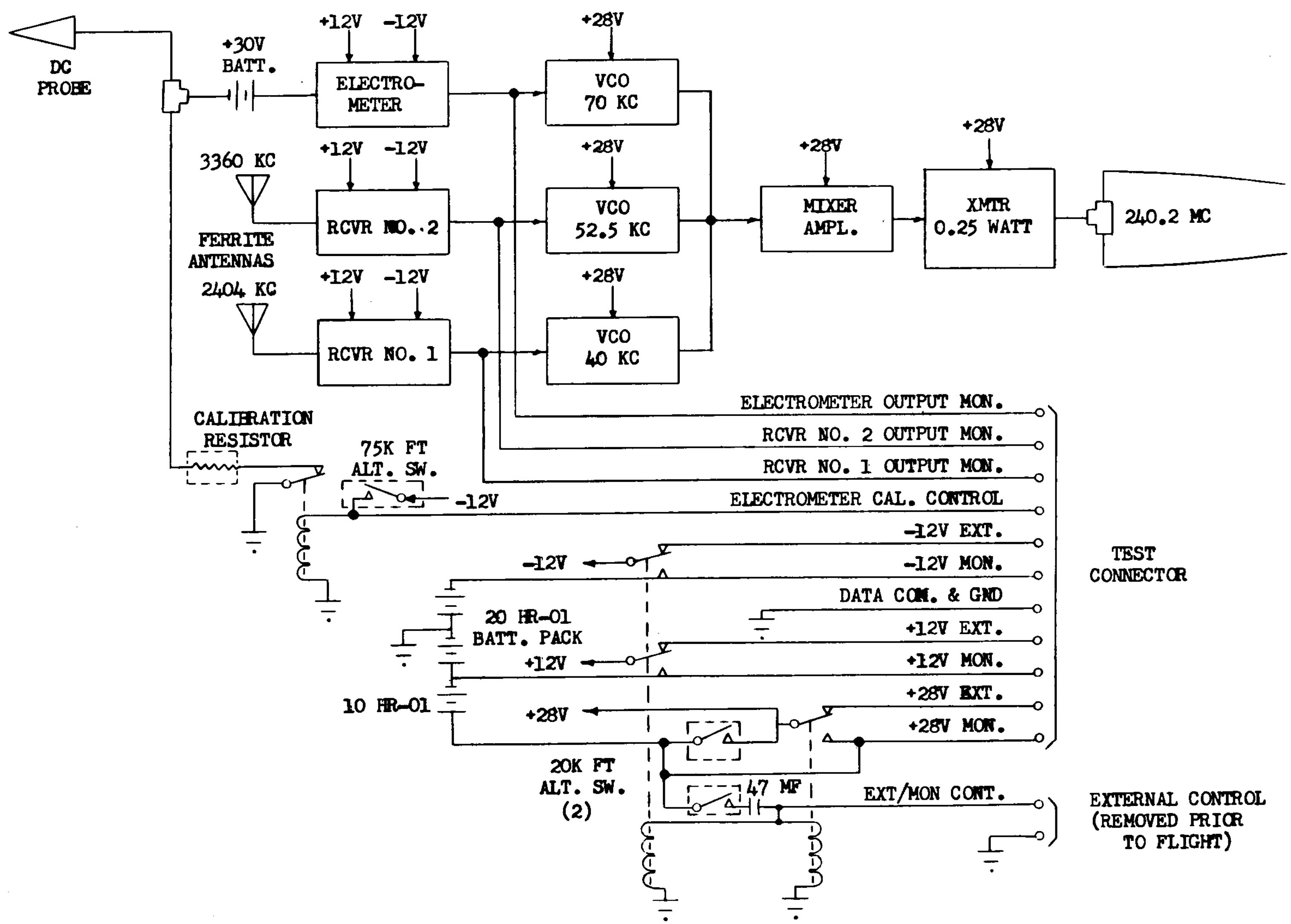


Figure 15. Telemetry and Instrumentation Block Diagram

Telemetry battery power, a portion of which was supplied to the experiment section, was provided by two packs of 10 and 20 Yardney model HR-01 Silvercells. Each cell was of the silver-zinc alkaline type using a potassium hydroxide solution as the electrolyte. Nominal cell rating was 1.5 volts at 0.1 ampere hour at room temperature. The cells were of the high rate (HR) discharge type; that is, total cell energy may be expended in less than one hour. Due to the small amount of electrolyte and absence of gassing, it was possible to install the battery pack in a pressurized box (Sheet 1, Figure 13) without a vent tube or sump.

INTEGRATION

All payloads were integrated and performance checked under simulated flight conditions prior to departure from GSFC. At the same time the rocket telemetry systems were checked against Sounding Rocket Instrumentation Section FM/FM ground telemetry station G to ensure that all payload elements were properly operating. The payload and nose cone assemblies were then delivered to the project scientists, who conducted further checks of the DC probe and radio propagation experiment circuits.

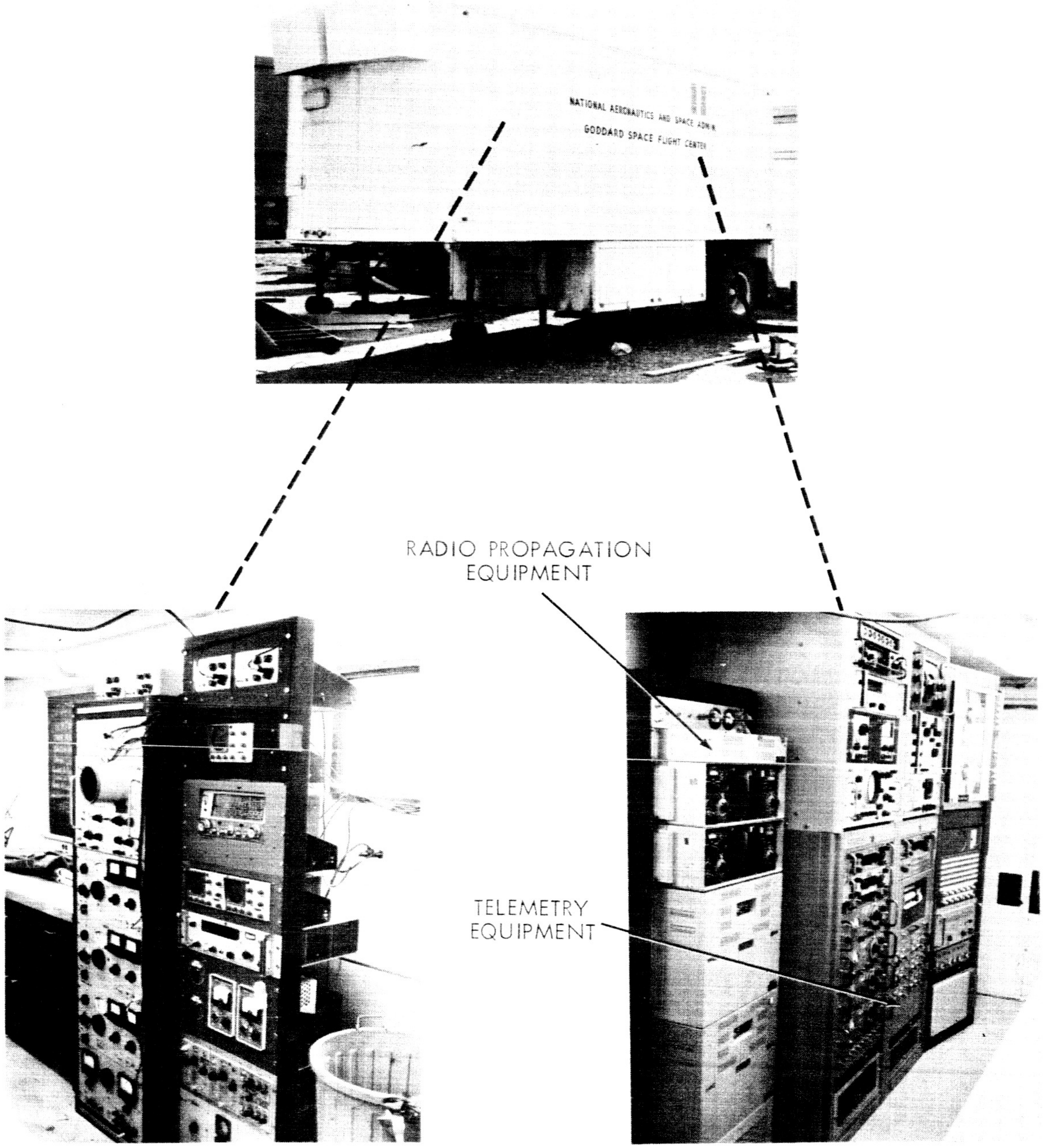
Project scientists and payloads arrived at the launch site on 14 May. The ground station and associated equipment had been well installed prior to the 14 May date. Payloads were immediately unpacked, inspected for transit damages, and given preliminary operational checks. At this time it was discovered that the KIWI 4 telemetry transmitter was not operating on the correct output radio frequency. It was not possible to correct this problem, therefore a spare transmitter was installed. All payloads were then found to be in operational condition.

GROUND STATION

A single transportable semi-trailer was found to offer the most economical and efficient method of housing the ground station telemetry and radio propagation experiment equipment. To best utilize the available space for telemetry and experiment equipment and still provide room for operating and maintenance personnel movement required a cooperative effort between Planetary Ionospheres Branch and Sounding Rocket Instrumentation Section personnel.

TRAILER DESCRIPTION

The ground station was housed in a 22-foot long single-axle semi-trailer (see Figure 16) about 7.5 feet wide and 80.25 inches high. Facilities included air conditioning, heating and lighting, workbenches, tool and spare part storage, and maintenance and test equipment racks. Double doors, located at the rear of the trailer, facilitated equipment installation while a single door for personnel use was at the front. Unloaded weight of the van was about 9000 pounds.



Test, Calibration, and Communications Equipment

Radio Propagation and Telemetry Equipment

Figure 16. Ground Station Interior Equipment Location

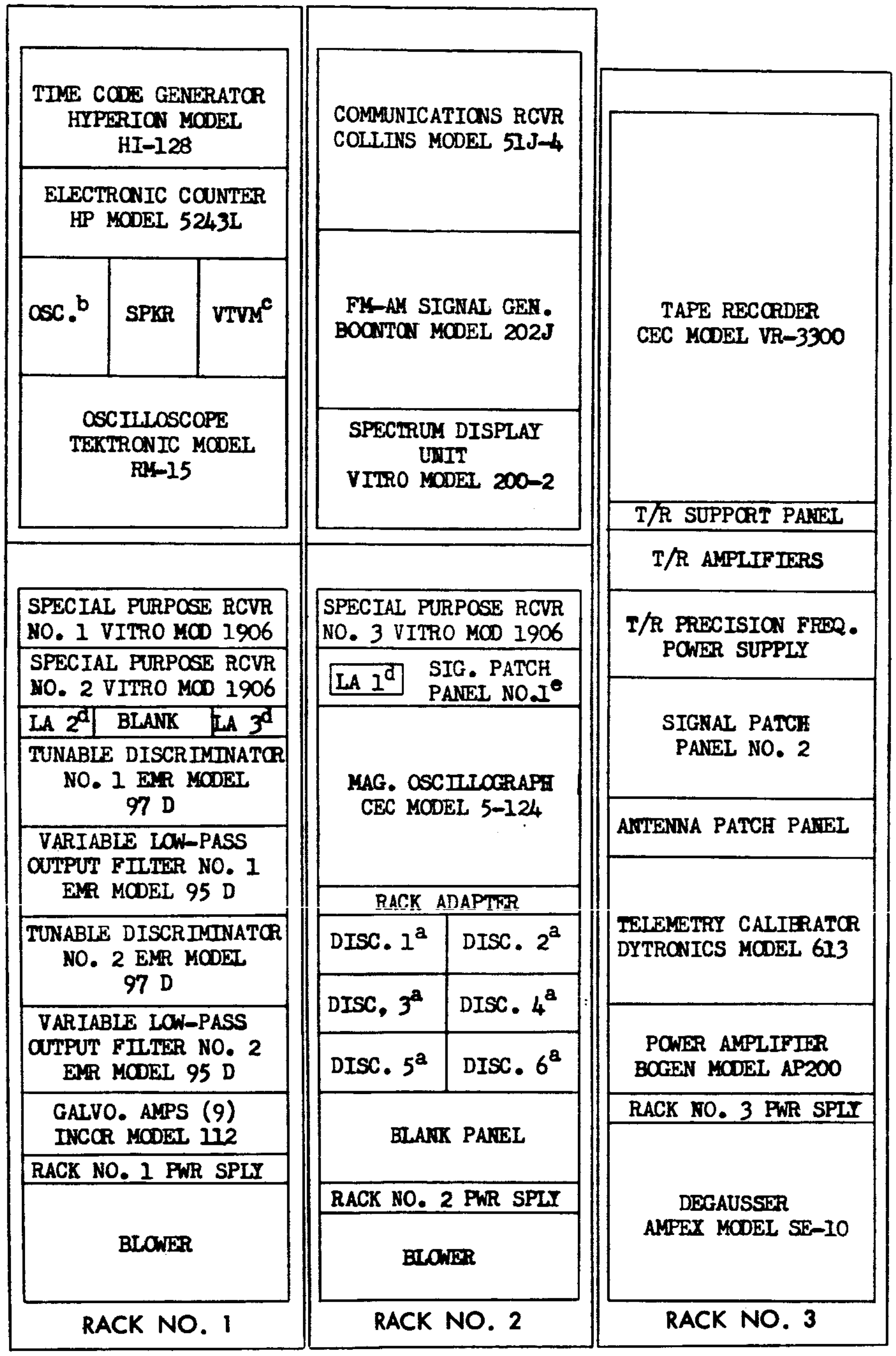
EQUIPMENT CHARACTERISTICS

FM/FM telemetry ground station equipment supplied by the Sounding Rocket Instrumentation Section was mounted in three standard six-foot relay racks located at the rear of the trailer. An almost equal amount of space was devoted to experiment equipment supplied by the Planetary Ionospheres Branch.

Telemetry and Instrumentation Equipment

The FM/FM ground station telemetry equipment consisted of helix and Yagi antennas, receivers for data acquisition, signal display units, discriminators for separating individual subcarriers from a composite signal, and magnetic tape and oscillographic recorders for storing and displaying acquired data. In addition, to ensure uninterrupted operation, sufficient instrumentation was included to test, calibrate, and maintain both the airborne and ground telemetry equipment. Figure 17 shows the various telemetry equipment unit locations together with model designations, while Figure 18 contains the block diagram.

A total of seven channels of data, as listed in Table 6, were recorded on magnetic tape for each flight at a tape speed of 60 inches per second. Simultaneously, a real time paper record of telemetry data was made. Composite signals of the telemetry video frequencies (70, 52.5, and 40 kcs) were discriminated using 790, 600, and 400 cps gausian low-pass output filters (LPOF).



LEGEND

[a]Discriminators Nos 1 thru 6 EMR Model 167A
[b]Oscilloscope HP Model 204B
[c]VTVM HP Model 403B
[d]Line Amplifiers Nos 1 thru 3 EMR Model 173A
[e]Signal Patch Panel No. 1 EMR Model 56-8213A

Figure 17. Telemetry Equipment Unit Locations

NOTES

1. Abreviations:
   TUN DISC - Tunable Discriminator
   SDU - Spectrum Display Unit
   LPOF - Low Pass Output Filter
   LA - Line Amplifier
   T/R - Tape Recorder
   GALVO. AMPS - Galvanometer Amplifiers
   PF PWR SPLY - Precision Frequency Power Supply

2. Refer to Figure 17 for complete unit designation and model number.

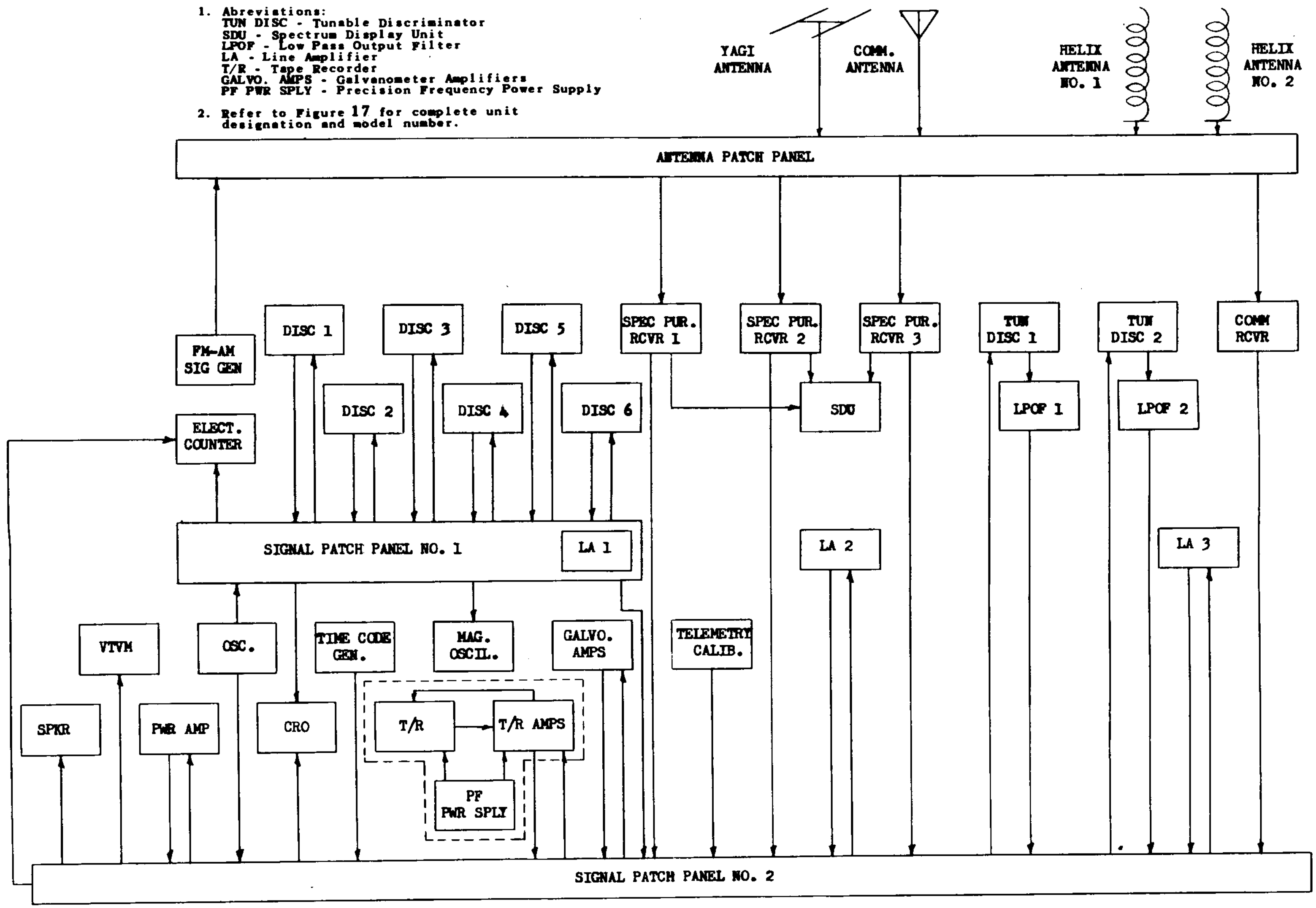


Figure 18. Telemetry Equipment Block Diagram

Table 6. Magnetic Tape Tracks

TRACK	DATA
1	Telemetry Receiver No. 1 Video
2	Telemetry Receiver No. 3 Video
3	Telemetry Doppler
4	Telemetry Receiver No. 2 Spin
5	Voice
6	Multiplex (36 Bit - 70 kc; 28 Bit - 52.5 kc; Timing 1 and 100 PPS - 30 kc; and Spin-Receiver No. 2)
7	Tape Speed Compensation (TSC) and 100 kc

Helix antennas 1 and 2 were employed to receive the 240.2 mc telemetry radio frequency carrier from the rocket payload. Each was an 8-turn right-hand circular helix with a frequency range from 230 to 270 mc. Gain and beamwidth were about 12 dB and 20 degrees, respectively with a nominal impedance of 50 ohms. Antenna pedestals were manually adjustable to allow tracking in both elevation and azimuth. Figure 19 illustrates helix antenna 1 and its component parts.

While the receiving antennas were circularly polarized to minimize signal loss due to rocket rotation, it was essential to the experiment that spin rate be known. This was accomplished with a linearly polarized Yagi antenna. Peaks and nulls of the receiver AGC were used to ascertain rocket spin rate. Time checks with Maui, Hawaii, National

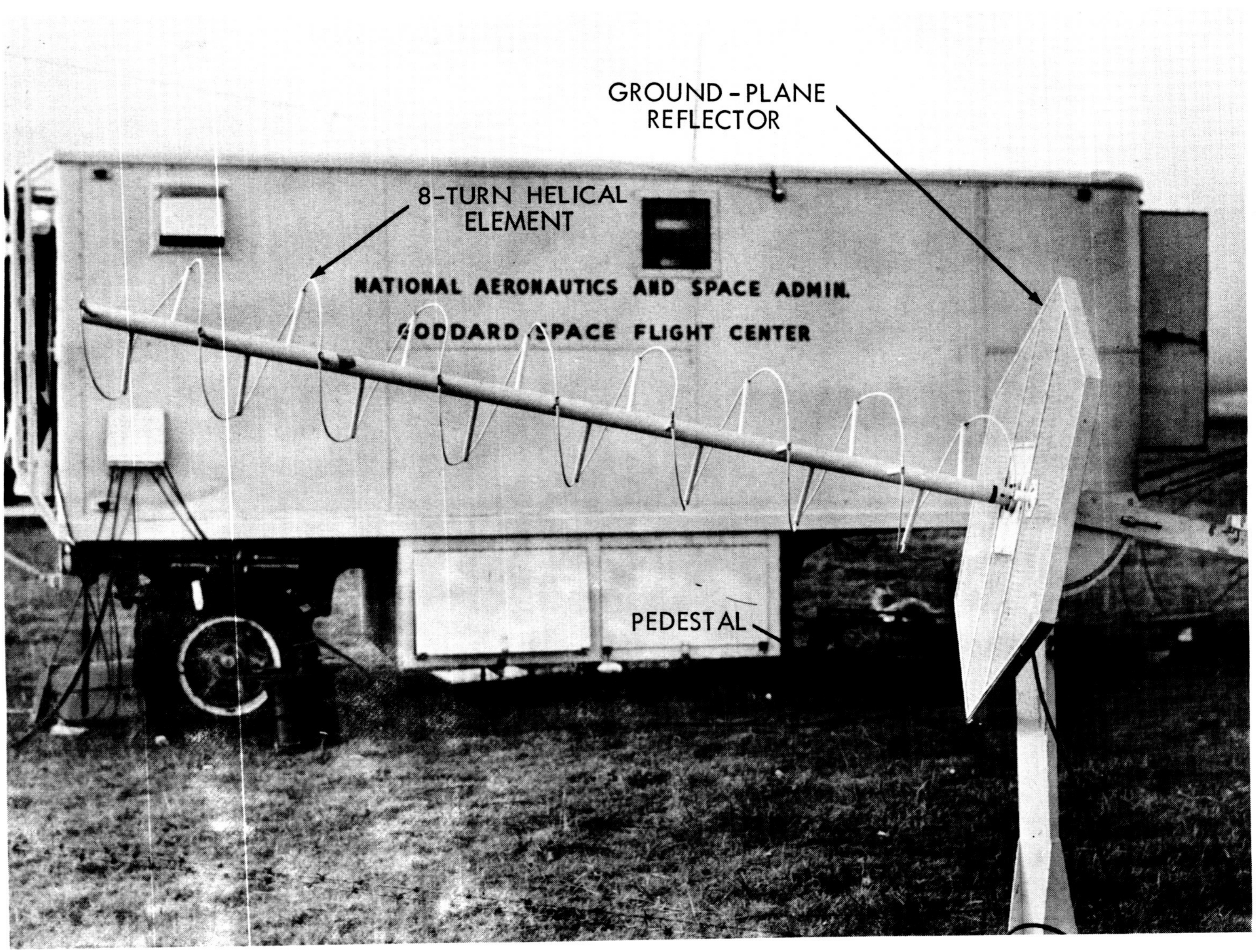


Figure 19. Helix Antenna No. 1

Bureau of Standards Station WWVH, as well as local New Zealand time, were performed using the Collins model 51J-4 communications receiver. The whip antenna fed this receiver in addition to a receiver used by the experimenter.

Radio Propagation Equipment

Radio propagation equipment supplied by the Planetary Ionosphere Branch included necessary test, calibration, and communication equipment (see Figure 16) to provide limited support. Two transmitters were employed, each consisting of a Collins model 367A-3 500 watt HF power amplifier. Radio frequency output range was from 2 to 30 mc. Power for the transmitters was obtained from Collins model 428B-1 high voltage power supplies rated at 2000 VDC, 600 ma, with less than 1.25% ripple. Combined weight of the two units was 114 pounds.

Test, calibration, and communications equipment was mounted in two adjoining racks, shown in the lower left of Figure 16. Test equipment included a Hewlett-Packard type 202A low frequency function generator to simulate payload signal return and oil-cooled dummy loads for performing transmitter checks. All equipment supplied in support of the Faraday rotation experiment is shown in Figure 20. Of the three signal generators shown, two were used as exciters for the Collins power amplifier and the other was for standby. The Heathkit model GC-14 communications receiver was used primarily to monitor for rf interference on the experiment transmitting frequency.

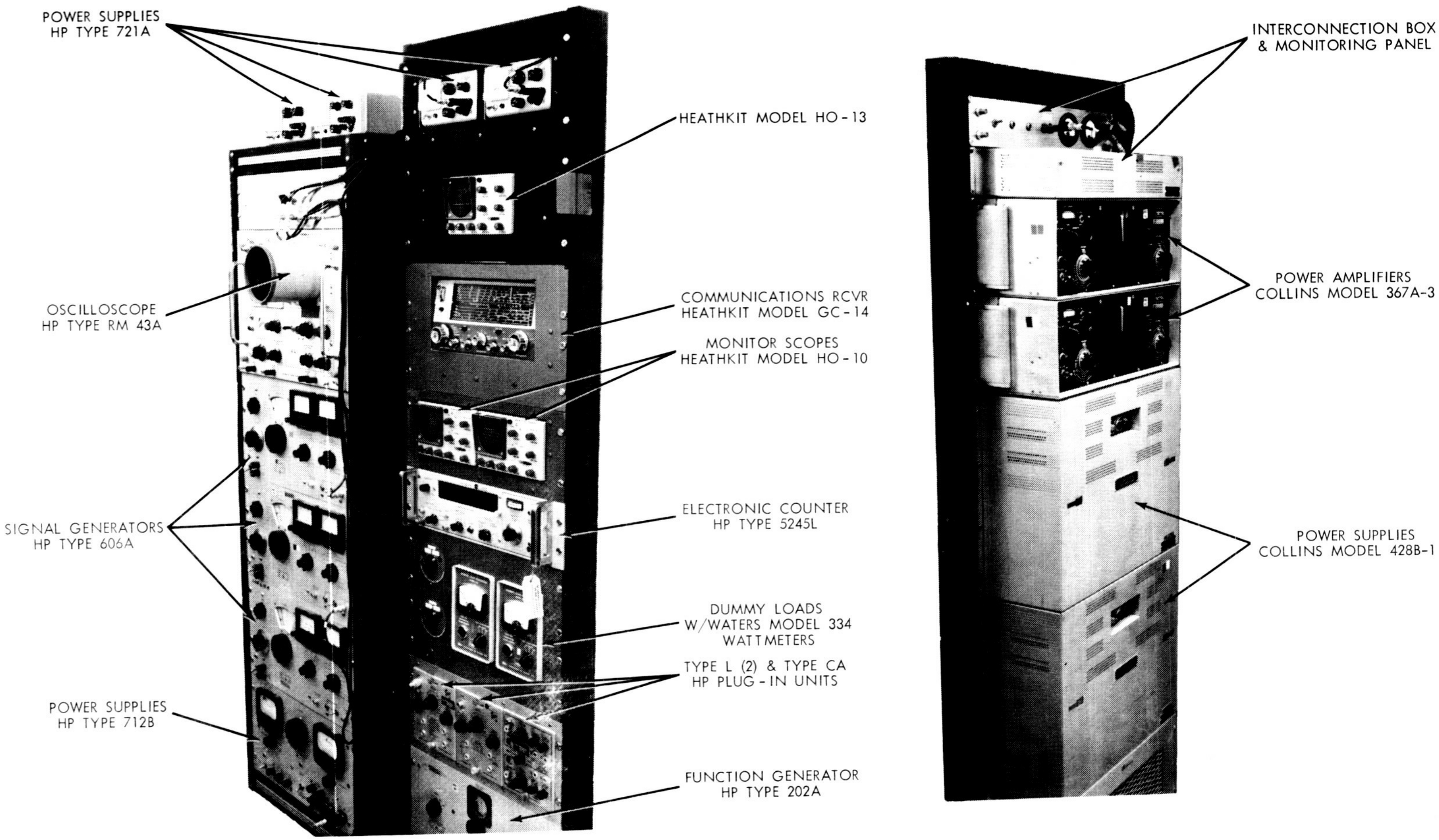


Figure 20. Radio Propagation Equipment Unit Locations

Two half wave center-fed balanced dipole antennas, installed between five antenna supports directly in line with each other (see Figure 21), radiated linearly polarized signals to the rocketborne receiving antennas. Each antenna was fed with 50-ohm unbalanced coaxial cable to match the transmitter 50-ohm unbalanced output. This unbalanced coax was matched to the antenna by means of a balun. The antenna supports were equipped with pulleys and ropes to allow antenna raising and lowering in order to obtain a 50-ohm impedance. Antenna supports were mounted within 2000 yards of the launchers, as it was desirable that they be located as close as possible. Although the line of direction was toward the launcher, this was not critical to the experiment.

EQUIPMENT INSTALLATION

The New Zealand National Space Research Committee Project Manager arranged with local contractors to supply construction equipment and services once basic installation requirements were established. As a result, the proper personnel, equipment, and material were readily available to the project when needed, thereby avoiding any delay in preparing the site and installing the equipment. Figure 22 shows an aerial view of the launch site and details of major installations.

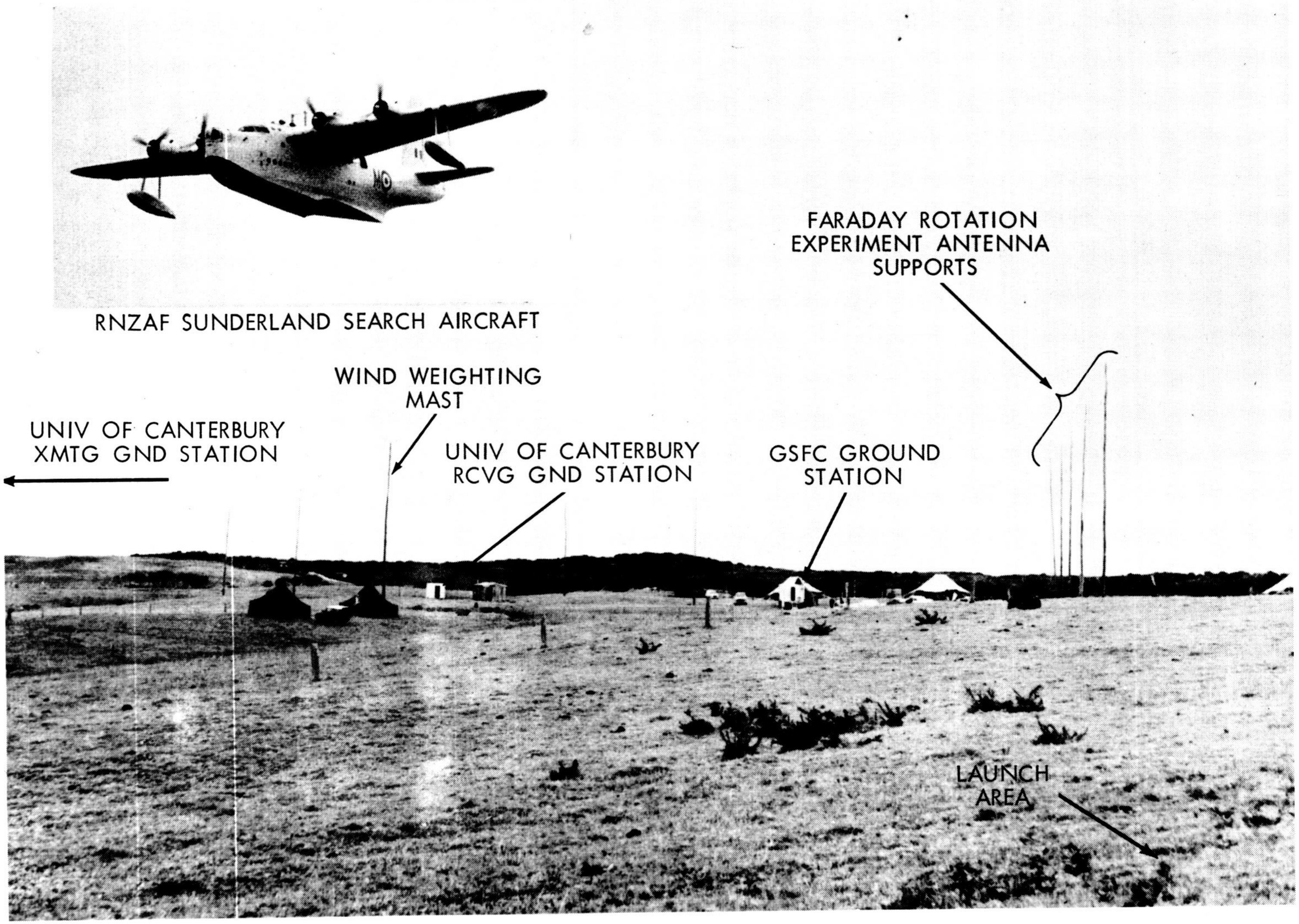


Figure 21. Equipment Site

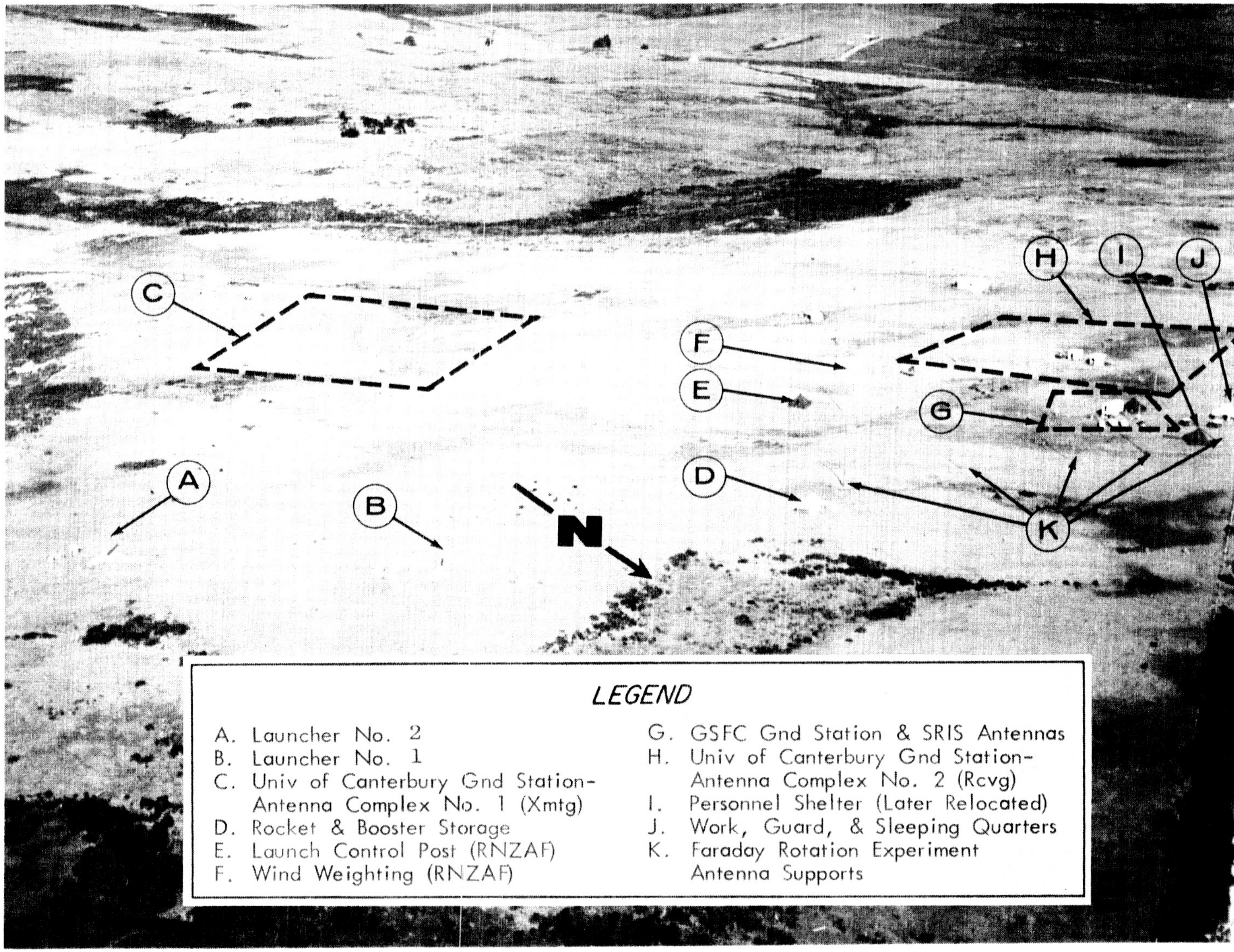


Figure 22. Aerial View of Launch Site

ROCKET LAUNCHERS

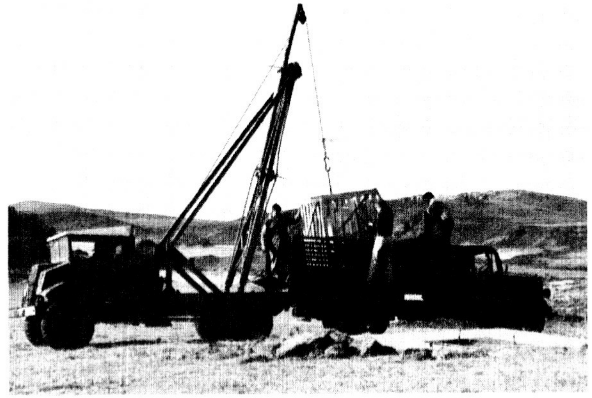
Launchers No. 1 and No. 2 (prime and alternate) were installed about 180 feet apart. The immediate areas were leveled and obstructions removed prior to pouring concrete for the launching pads. Each pad was 12 feet square and 8 inches thick and embedded with three 10-inch bolts to accommodate the Arcas launcher. Figure 23 shows some of the steps involved in mounting the launchers.

Preparatory to launch tube installation, the azimuth table was leveled. Next, the lower section of the launch tube was installed, and then the middle and upper sections were joined. Using a theodolite, the launch tube was aligned after assembly and the connecting bolts were alternately tightened. Figure 24 shows Launcher No. 1 after final assembly. Normally, when not in use, the launcher is locked in the vertical position with the open end of the launch tube covered by a tarpaulin for protection against weather.

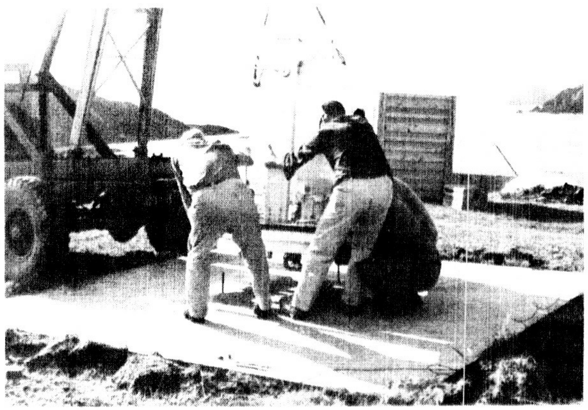
GROUND STATION

All ground station equipment was installed in the 22-foot trailer prior to leaving GSFC; therefore, the installation procedure in New Zealand consisted simply of locating the trailer in the proper position and assembling and spotting the antennas. The ground station trailer arrived at the site mounted aboard a flat-bed trailer, as long distance direct towing was impossible due to hitching incompatabilities. The

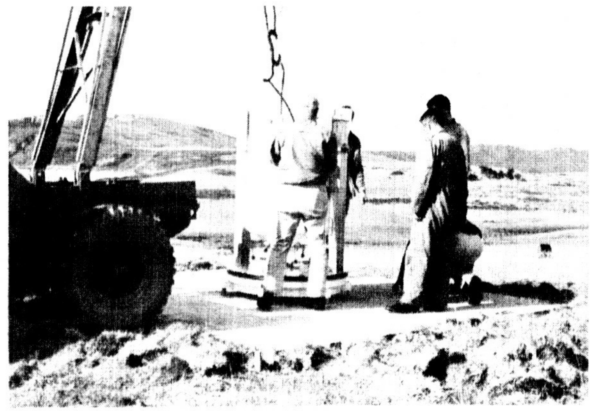
1. Planning the Unloading Operation.



2. Hoisting Crated Free - Volume Cylinder and Azimuth - Table Adjacent to Concrete Launch Pad.



3. Assembly Positioned Over Anchoring Bolts After True N-S Line has been Marked.



4. Assembly Anchored in Place Preparatory to Leveling Procedure and Installation and Alignment of Launch Tube.

Figure 23. Preliminary Launcher Installation Sequence

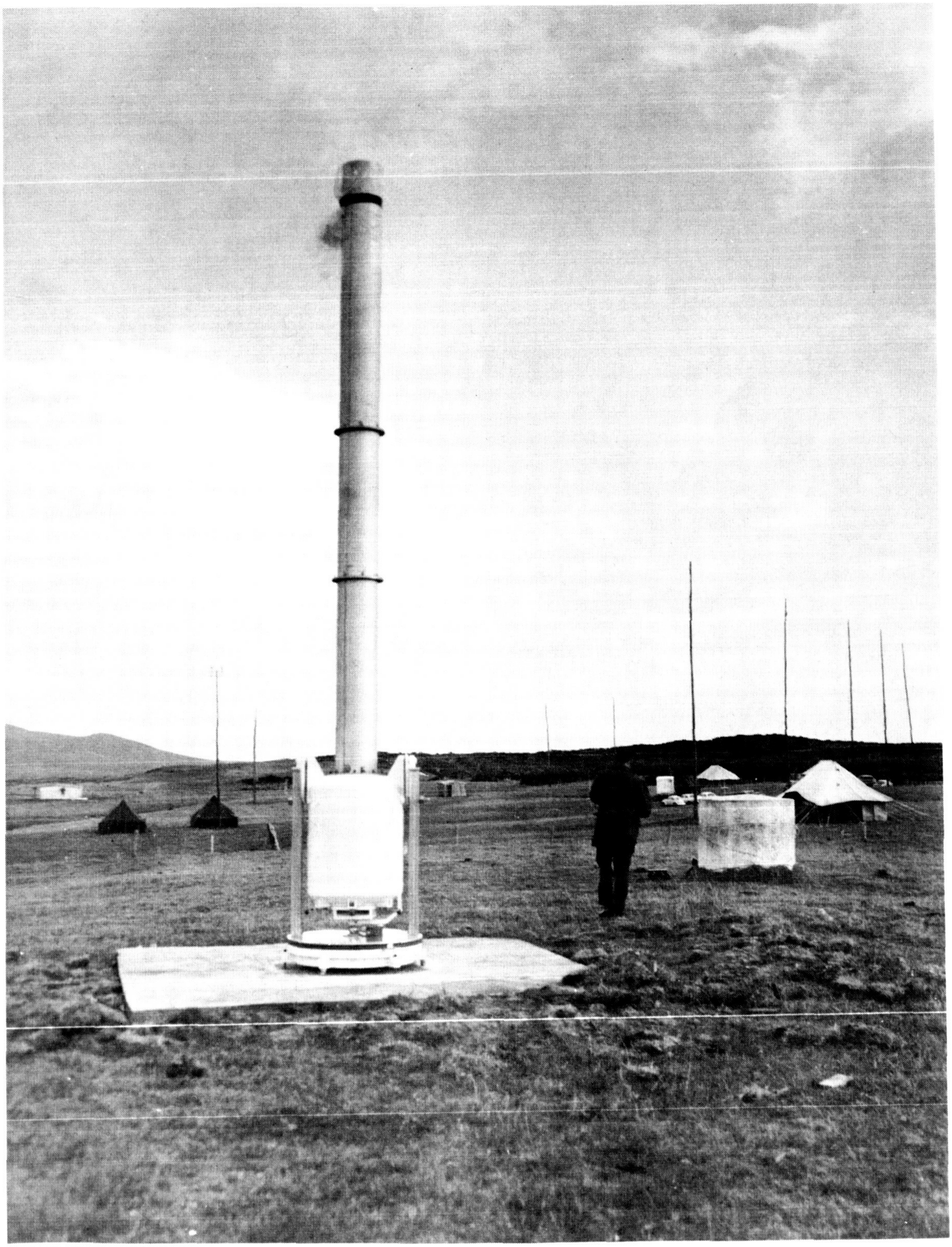


Figure 24. Launcher No. 1 Installed

trailer was removed from the flat bed and later moved by tractor to a location about 300 feet from the launchers. Figure 25 shows the different hauling arrangements.

After the ground station was established, the telemetry antennas were assembled and located about 10 feet on either side of the trailer facing the launchers (refer to Figure 26). Then the Yagi antenna (for measurement of rocket spin) was mounted atop the trailer as shown.

WIND WEIGHTING AND EXPERIMENTAL ANTENNA SUPPORTS

A total of 14 wooden supports or masts were required: five to support the GSFC radio propagation experiment antennas, eight for the University of Canterbury differential absorption experiment, and one for the wind weighting equipment. The supports ranged in height from 60 to 80 feet and were located as shown in Figure 22. All masts were provided and transported to the site by New Zealand. Figure 27 shows the steps involved in erecting the wind weighting support; installation of the antenna supports was performed in a similar manner.

NEW ZEALAND EQUIPMENT

Facilities supplied and installed by the University of Canterbury and the RNZAF included the receiving and transmitting differential absorption experiment facilities, a wind weighting station, a launch control post, and various tents (see Figure 22) for housing personnel and spare equipment.

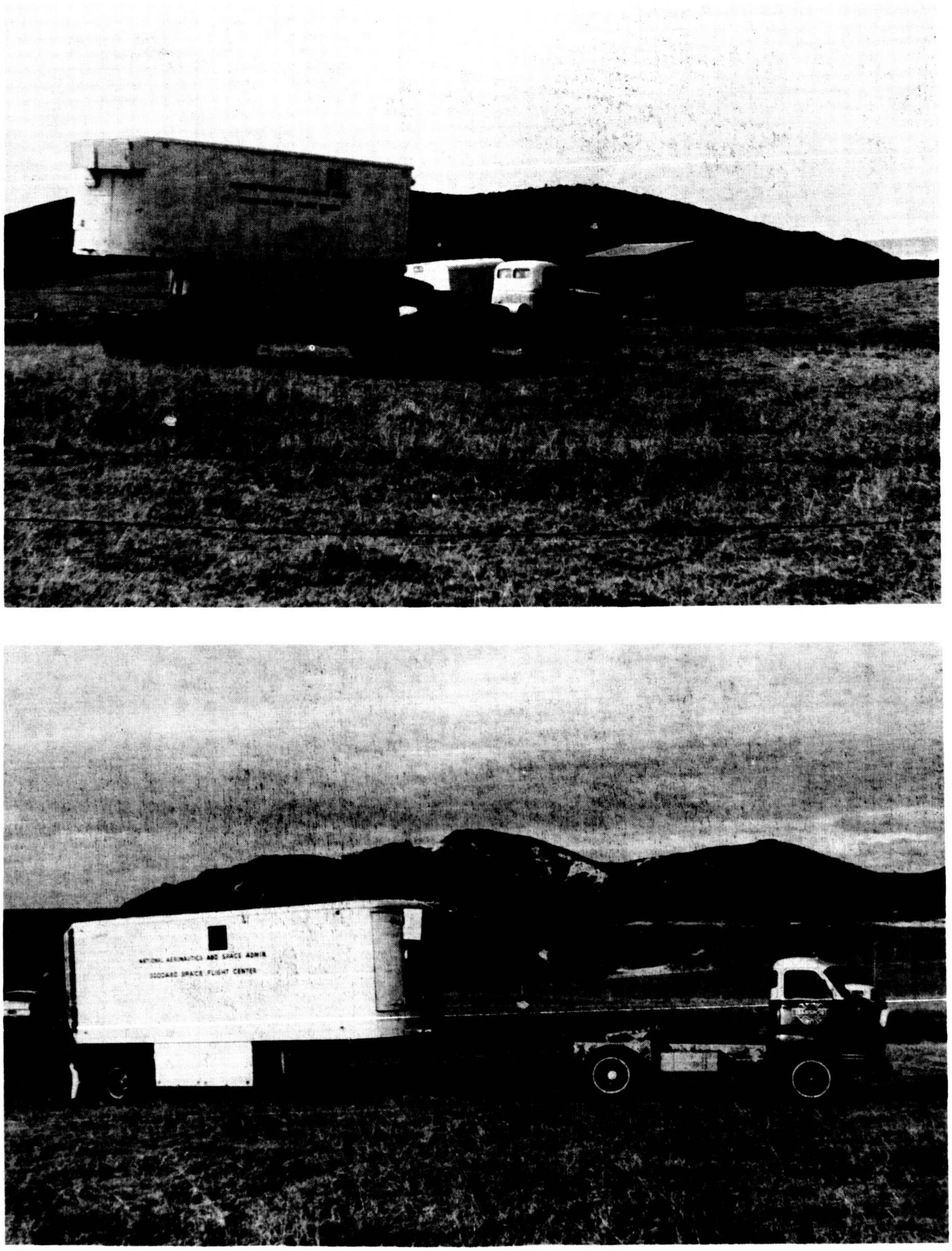


Figure 25. Ground Station Emplacement

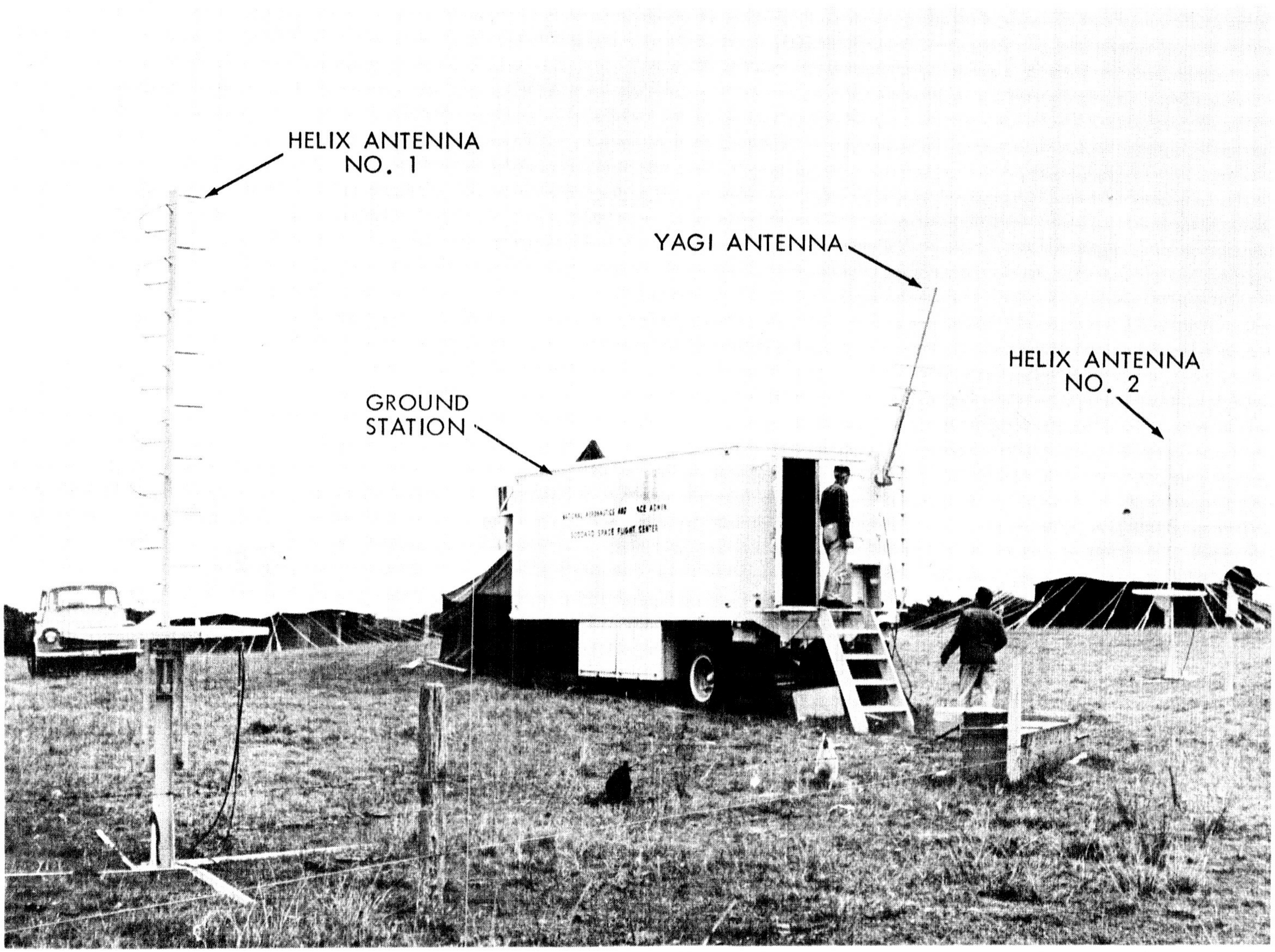
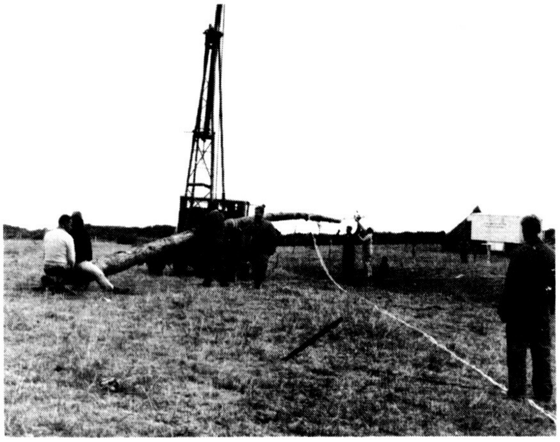
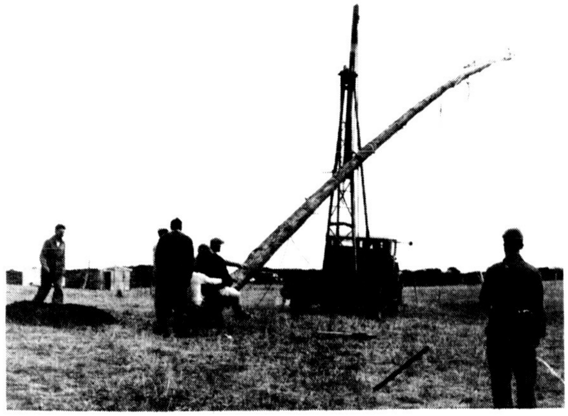
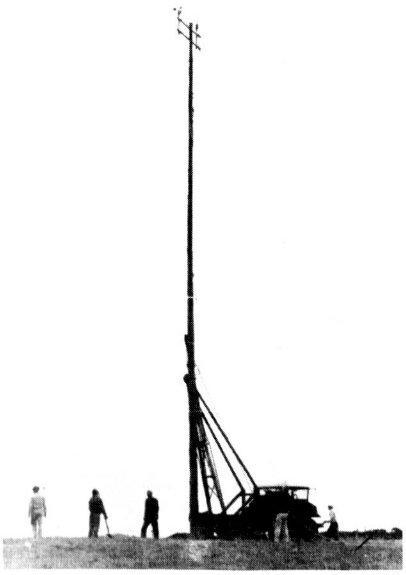


Figure 26. Ground Station Antenna Installation







Top left to right. (1) Spotting Augar Adjacent to Staked Location. (2) Preliminary Digging Operations. (3) Support and Crane Moved into Position and Final Check of Equipment and Guy Wires. (4) Hoisting Support to Vertical Position. (5) Final Installation.

Figure 27. Typical Support Installation Sequence

Receiving and transmitting stations were each contained in a trailer. Station installation was simply a matter of placing each trailer in the proper location and erecting the four associated antenna supports. Figure 28 shows the ground stations being towed to the site and the transmitting station as finally installed. Installation layout of the receiving station was similar.

KIWI 1 PRE-ECLIPSE LAUNCH PREPARATIONS

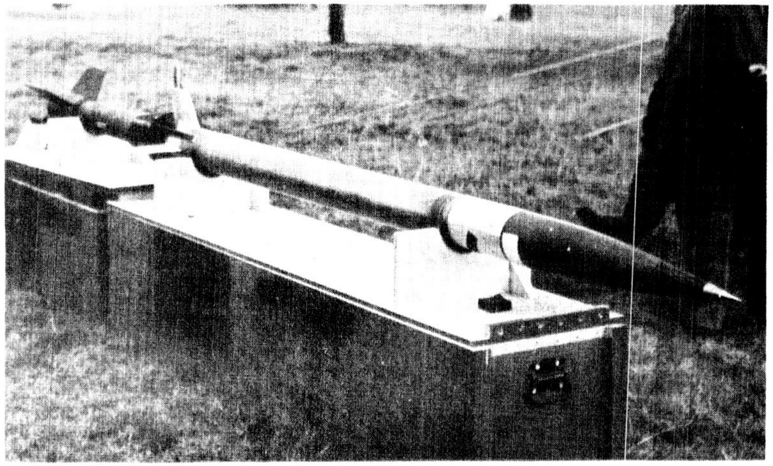
All Arcas rocket motors, boosters, and ignitors which had been delivered to the RNZAF Hobsonville facility for storage were delivered to the launch site and preparations were made for the KIWI 1 familiarization firing. Meanwhile, final checks were made of equipment installations and communication lines. The RNZAF launch team, some of whom had previously fired the unboosted Arcas, were given instruction in Boosted Arcas handling techniques. A number of loading familiarization runs, under direction of the NASA vehicle manager (refer to Figure 29), were then conducted using the actual vehicle.

Areas of responsibility concerning launch operations, e. g., posting of guards, fire-fighting personnel, medical aid, and range safety, had been well defined in range orders issued by RNZAF Hobsonville (refer to Appendix C). Consequently, there was a minimum of prelaunch time spent in RNZAF personnel orientation. The preshoot conference was chiefly limited to briefing representatives of the cognizant

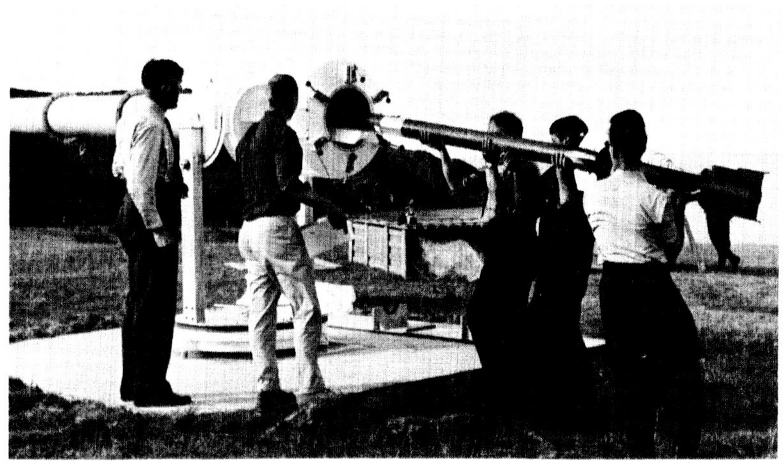
Rcvg and Xmtg Stations Enroute to Site

Transmitting Station Installed

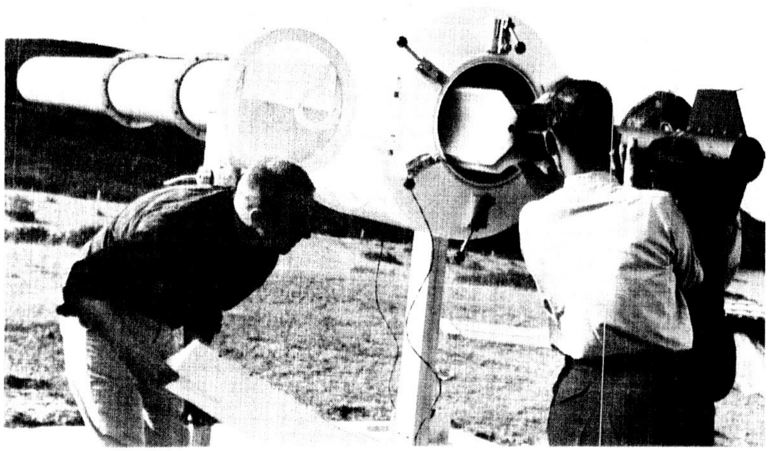
Figure 28. University of Canterbury Ground Stations



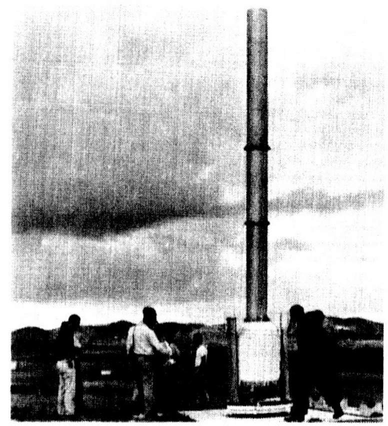
1. Boosted ARCAS Preparatory to Loading.



2. Assembled Launcher Receiving Rocket.



3. Installation of Fourth Plastic Launching Spacer.



4. Launcher Elevated to Firing Position.

Figure 29. Launcher Loading Sequence

groups as to programmed event times and discussing the schedule of operations (refer to Table 7). Particular emphasis was placed on the importance of safety aspects of the operations. Included was a discussion of the basic rocket firing circuit (see Figure 30).

A special weather forecast that had been made for the Cape Karikari area predicted winds of 20 to 30 knots with gusts to 40 knots and heavy rain for the day of launch. Such conditions, of course, would preclude any launch attempt. However, New Zealand weather conditions are somewhat variable and the firing schedule was retained with launch time advanced to 2000Z hours (8:00 A.M. New Zealand time). Revised times are given in the Table 7 schedule.

The RNZAF Sunderland search aircraft (Figure 21 insert) detected several vessels in or near the impact area a few hours prior to launch. A Japanese fishing boat, a New Zealand freighter, and a trawler, after being communicated with, promptly moved away.

Weather conditions at dawn were marginal, but steadily improving. Precipitation became light and, in the last hour before launch, the wind weighting facility reported winds reduced to five knots. This was well within range safety requirements and final flight preparations were initiated.

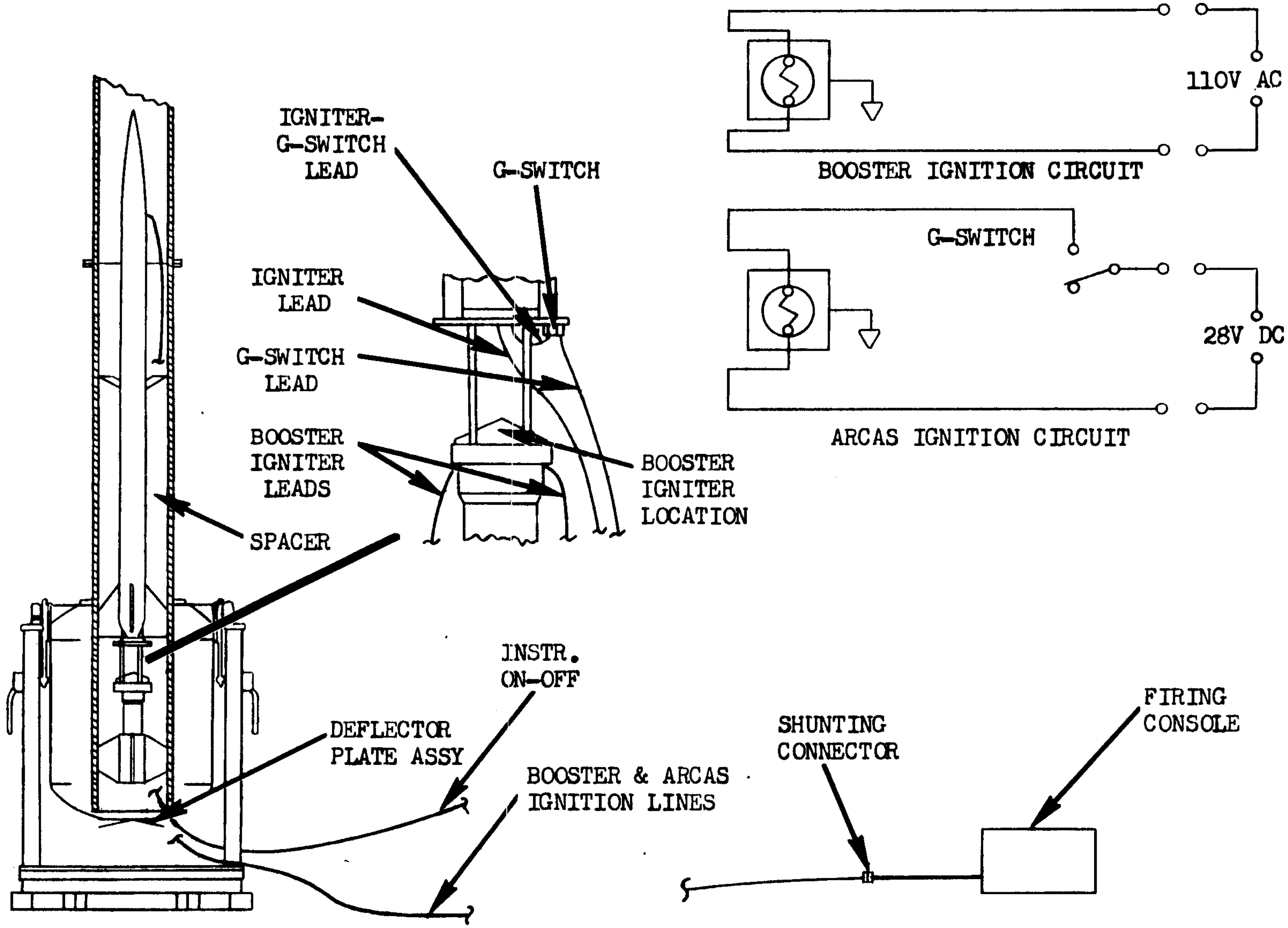


Figure 30. Rocket Firing Schematic Layout

Table 7. KIWI 1 Pre-Eclipse Launch Countdown

SCHEDULE			ACTION[b]		
TIME[a]	COUNTDOWN	PROGRAM	FROM	TO	OPERATION
0629	T-90 min	Site conference	RSO	LC	Status reports to controller.
			Pads	LC	
			Inst.	LC	
			WW	LC	
			DAE	LC	
0634	T-85	Authorize loading	LC	Pads	Load prime and alternate launchers.
0659	T-60	Wind check.	WW	LC	Launcher setting to pads.
		Preliminary launcher settings.	LC	Pads	
0729	T-30	Safety check.	RSO	LC	Range sector and danger areas safety check.
			LC	Pads	Confirm prime and alternate launcher ignitor shunts.
		DAE observation.	LC	DAE	Authorize DAE.
		Final launcher settings.	WW	LC	Prime and alternate launcher settings.
			LC	Pads	
0752	T-7	Radiation check.	LC	DAE	Command DAE off.
			LC	Tel	Check telephone off.
			LC	Pads	Check prime and alternate launcher settings.
			LC	Pads	Authorize ignitors connected.
			LC	Pads	Authorize payload plug in.
			Pads	LC	Advise pads vacated.
0754	T-5	Instrumentation check.	LC	RSO	Check local danger area.
			LC	Inst	Authorize instrumentation check.
0758:30	T-30 sec	Safety checks	LC	RSO	Safety status and range check.
			LC	WW	Wind checks.
			LC	Inst	Instrumentation check.

Table 7. KIWI 1 Pre-Eclipse Launch Countdown (Cont.)

SCHEDULE		PROGRAM	ACTION[b]		OPERATION
TIME[a]	COUNTDOWN		FROM	TO	
0758:40	Count T-0				
0759:00		Ignition			
0759:07		Booster down			
0759:30		Burnout			
0803:54		Impact			
0804	T+5 min	Radiation check	LC	Inst	Check radiation off.
		Ignitor disconnect	LC	Pads	Authorize ignitors disconnect and shunt.
			Pads	LC	Confirm ignitors shunted.
		Unload (optional)	LC	Pads	Unload alternate launcher.
0805	T+6	DAE observation	LC	DAE	Authorize DAE on.
0812	T+12	DAE observation	LC	DAE	Command DAE off.

[a] New Zealand Standard Time

[b] Abbreviations:

LC - Launch Control
WW - Wind Weighting
DAE - Differential Absorption Experiment (Univ. of Canterbury)
RSO - Range Safety Officer
Inst. - Instrumentation

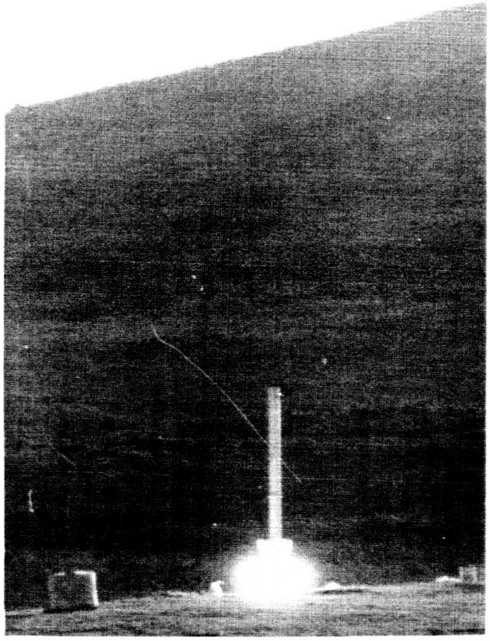
FIRING DATA

Final telemetry checks, performed while the vehicle was in the launch tube, showed that all telemetry channels were operating normally. The countdown then proceeded according to schedule, and at 1959Z hours KIWI 1 (Flight 15.18 GI) was successfully launched (see Figure 31). The quick look real time record confirmed operation of all telemetry channels with excellent data. Telemetry was recorded for 312 seconds and rocket performance (1, Table 8) was excellent. Projected apogee, calculated from the telemetry record, was 88 km.

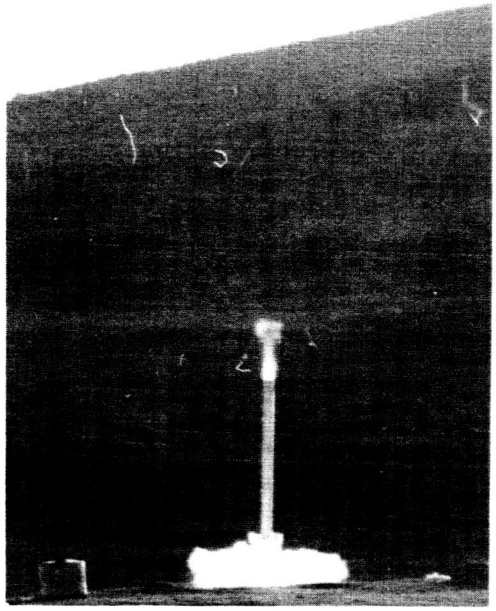
SOLAR ECLIPSE LAUNCHINGS

Due to the excellent performance of all personnel and equipment during the KIWI 1 familiarization pre-eclipse launching, it was decided to cancel the May 28 test firing, as the payload would serve a more useful purpose if launched during the eclipse. Equipment was rechecked and preliminary results of the test launching studied during the ensuing four days.

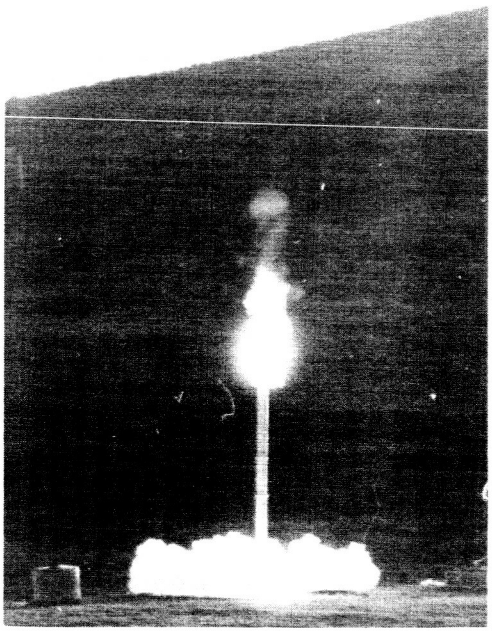
The preparation of flight batteries for the eclipse launchings was undertaken immediately following the successful KIWI 1 firing. A measured amount of electrolyte was added by hypodermic syringe to 180 cells in addition to 30 spare cells. After filling, the cells were set aside for a soaking time of 72 hours to allow for charge formation.



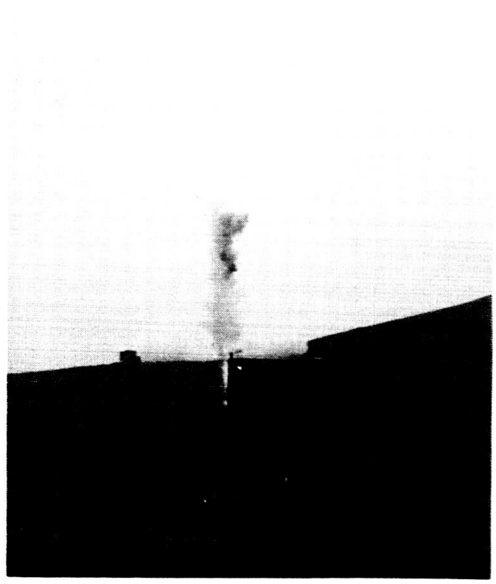
1. Booster Ignition
(T+0.04 Seconds).



2. Sustainer Ignition
(T+0.08 Seconds).



3. T+0.16 Seconds.



4. Lift-off (T+≈0.62 Seconds).

Figure 31. Flight 15.18 GI (KIWI 1) Launch Sequence

Table 8. Firing Data

ITEM	FLIGHT NUMBER	RANGE NUMBER	LAUNCH TIME (Z HOURS)	EFFECTIVE LAUNCH ANGLE		ACTUAL LAUNCHER SETTING		LAUNCH DATE	FLIGHT DURATION (SEC)
				AZIMUTH	ELEVATION	AZIMUTH	ELEVATION		
1	15.18 GI	KIWI 1	1959	032°	85°	n/a	n/a	25 May 65	312
2	15.05 GI	KIWI 2	1900	032°	85°	056°	84°	30 May 65	333
3	15.06 GI	KIWI 3	1920:24	032°	85°	056°	83.2°	30 May 65	299
4	15.07 GI	KIWI 4	1940:05	032°	85°	062°	83°	30 May 65	315
5	15.08 GI	KIWI 5	2000:01	032°	85°	062°	84.5°	30 May 65	336
6	15.09 GI	KIWI 6	2020:01	032°	85°	055°	84°	30 May 65	331
7	15.10 GI	KIWI 7	2100:02	032°	85°	055°	84°	30 May 65	317

After the soaking period, voltage checks were performed on each cell. Thirty cells were then installed in each payload and voltage checks repeated after one minute of normal payload operation. It was not until a few hours before the eclipse launchings that a current leakage path was discovered between the battery terminals and ground. This problem was present in four of the six payloads. Although the leakage was only on the order of 4 milliamps, the possibility existed of its becoming excessive and causing the batteries to be discharged prior to launching. The problem was solved by rerouting the battery ground through a set of spare contacts on the power transfer relay. All NASA/GSFC personnel then worked throughout the night to make the necessary modifications, and on the morning of launch all payloads were found to be satisfactory and ready for launch.

A few hours prior to the first eclipse launch an unidentified vessel was discovered in the impact area by the RNZAF Sunderland search aircraft. The vessel promptly moved away after the aircraft fired a red warning flare.

Weather conditions were ideal as the countdown of KIWI 2 proceeded according to schedule (refer to Table 9), and at precisely 1900Z hours the first eclipse launch was successfully accomplished (see Figure 32). Apogee was about 88 km (2, Table 8) while telemetry was recorded for 333 seconds with negligible dropout.

Table 9. KIWI 2 Launch Countdown

TIME*	EVENT	OPERATION
0500	1	Deliver payload to preparation area.
0545	2	Preflight conference.
	3	Status reports from RSO, Launch Officer, Wind Weighting, Instrumentation, DAE, and Power Facility
0600	4	Time check.
0605	5	Load prime and alternate launchers.
	7	DAE as desired.
0630	8	Launcher settings from wind weighting.
	8	Range safety check with RSO.
0646 (T-14)	9	Start final telemetry checks.
	10	Start final DAE.
0653 (T-7)	11	Radiation off.
	12	Ignitors connected.
	13	Local danger area cleared.
0655 (T-5)	14	Vacate launch pads.
	15	Instrumentation check.
0658 (T-2)	16	Start count.
	17	Instrumentation, Wind Weighting, and Controller on open line.
0700 (T-0)	18	Ignition - first launch.

*New Zealand Standard Time

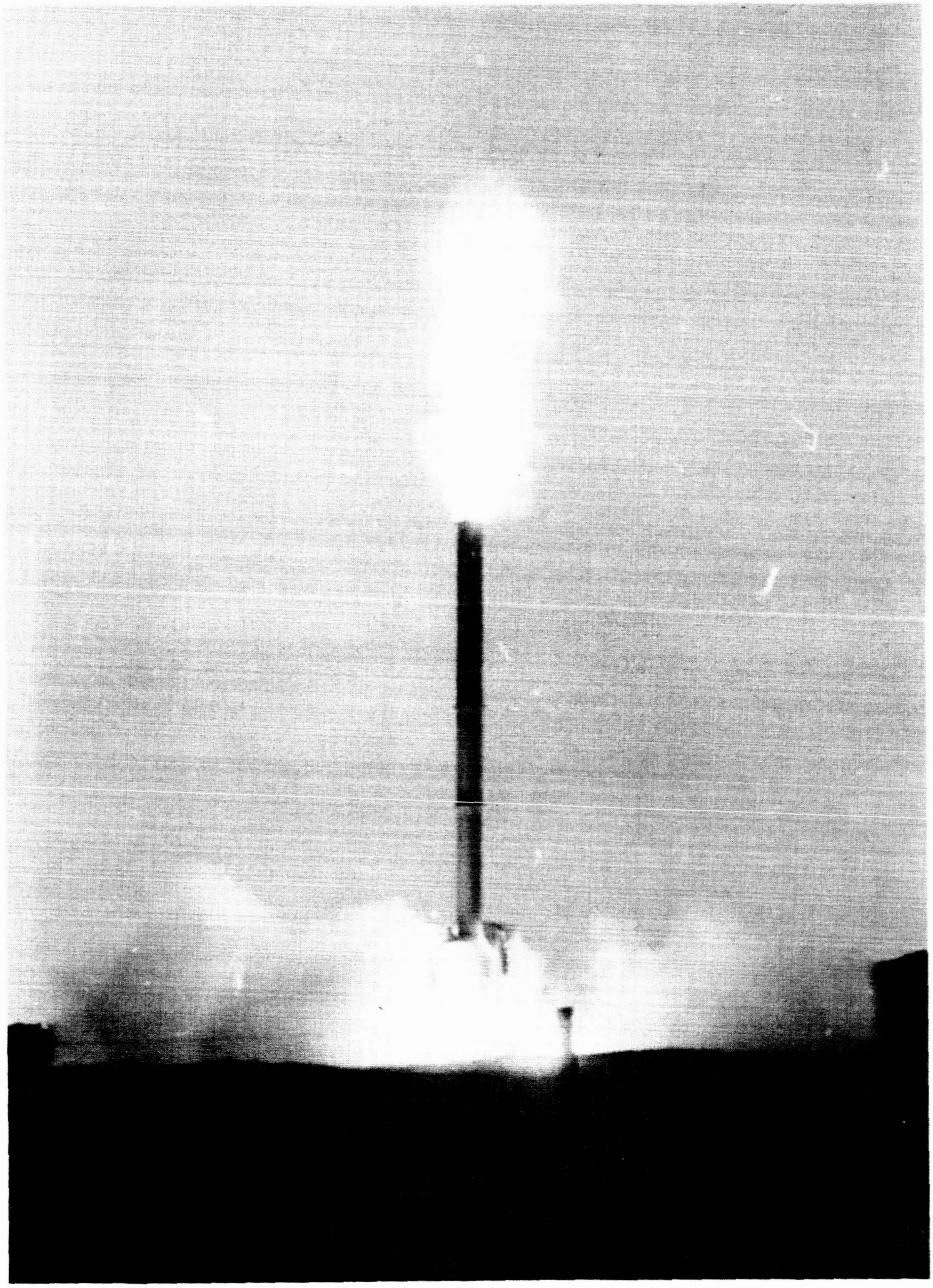


Figure 32. Flight 15.05 GI (KIWI 2) Ignition

As the solar eclipse underwent the various contact phases, KIWI's 3 through 7 were launched precisely on schedule (Table 10). All telemetry functioned normally with negligible dropout. Projected apogees of all rockets approximated 88 km, and data reception time varied from 299 to 336 seconds (3 through 7, Table 8). Figures 33 and 1 show KIWI 3 and KIWI 4 launches, respectively.

Table 10. Countdown Schedule KIWI 3 thru KIWI 7

COUNT-DOWN	TIME*					OPERATION
	KIWI 3	KIWI 4	KIWI 5	KIWI 6	KIWI 7	
	0702	0722	0742	0802	0822	Load
T-14	0706	0726	0746	0806	0826	Telemetry completed. Start new TM check. Start DAE. Reset launcher.
T-7	0713	0733	0753	0813	Pause 0913	Radiation off. Ignitors connected. Local danger area cleared.
T-5	0715	0735	0755	0813	0915	Vacate pads Instrumentation check.
T-2	0718	0738	0758	0818	0918	Start count. Telephone open.
T-0	0720	0740	0800	0820	0920	Ignition.

*New Zealand Standard Time.

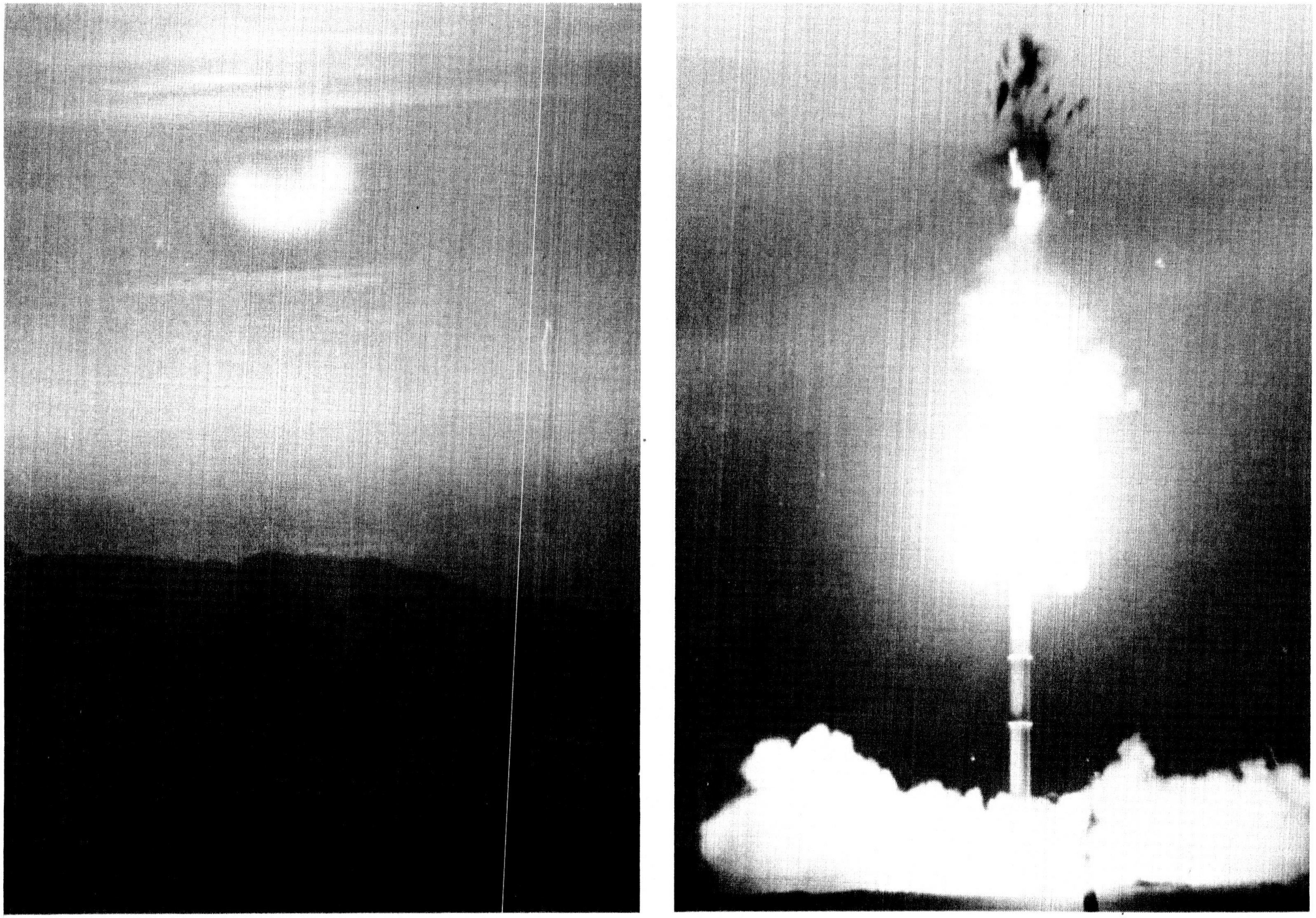


Figure 33. Flight 15.06 GI (KIWI 3) Launch at Partial Eclipse

CONCLUSIONS

All rockets were launched precisely on schedule and attained the desired peak altitudes. Excellent data were obtained as telemetry was recorded with negligible dropout throughout the duration of each flight. Experimental objectives were met in every respect and, pending final analysis, excellent results are anticipated. Although two launchers were installed, the project could well have been successfully accomplished using a single launcher.

ACKNOWLEDGMENTS

GSFC acknowledges the generous and competent support provided by all New Zealand participating activities. Successful completion of the project is attributable in great part to the able leadership of New Zealand groups by Dr. J.R. Gregory. Thanks are also due personnel of the Royal New Zealand Air Force for the outstanding cooperation rendered in the area of launch support services. Finally, the cooperation extended by University of Canterbury scientific personnel, who willingly assisted the project in any manner required, was greatly appreciated.

APPENDIX A

EQUIPMENT DATA

Table A-1 of Appendix A includes a complete list of telemetry, test, and maintenance equipment supplied by the Sounding Rocket Instrumentation Section in support of the Solar Eclipse Project. Table A-2 contains equipment supplied by the Planetary Ionospheres Branch, while Table A-3 contains cargo and performance capabilities of the C-124 transport.

Table A-1. Telemetry Equipment

ITEM	DESCRIPTION	MANUFACTURER & MODEL NO.	QTY.
1	Generator Time Code	Hyperion, HI-128	1
2	Electronic Counter	Hewlett-Packard, 5245L	1
3	Frequency Converter	Hewlett-Packard, 5253B	1
4	Oscillator	Hewlett-Packard, 204B	1
5	Voltmeter	Hewlett-Packard, 403B	1
6	Oscilloscope	Tektronix, RM15	1
7	Receiver	Nems-Clarke, 1906	3
8	Discriminator	Electromechres, 97D	2
9	Filter Low Pass Output	Electromechres, 95D	2
10	Galvanometer-Amplifier	Incor, 103B	1
11	Signal Generator	Boonton, 202J	1
12	Spectrum Display Unit	Vitro, 200-2	1
13	Oscillograph	Conslelectrodyn, 5-124	1
14	Discriminator-Subcarrier	Electromechres, 167A-01	6
15	Stereo Amplifier	Bogen, AP 200	1
16	Degausser	Ampex, SE-10	1
17	Degausser	Conslelectrodyn, VR-3300	1
18	Calibrator-Telemetry	Dytronics, 613	1
19	Receiver	Nems-Clarke, R1037A	1
20	RF Tuner	Nems-Clarke, RFT101A	1
21	Spectrum Display Unit	Nems-Clarke, SDU364	1
22	Demodulator	Vitro, FSD-105A	1
23	Tape Recorder	Precision Instruments, PS207A	2
24	Power Supply	Kepco, ABC40-0.5M	2
25	Take-up Reed	Conslelectrodyn, 5-059	1
26	Amplifier	Hewlett-Packard, 466A	2
27	Wattmeter	Bird, 61	2
28	Digital Scaler	Western Reserve, 300	1
29	Speaker Console	Collins, 312B-5	2
30	Transmitter	Collins, KWM-2	2
31	Power Supply	Hewlett-Packard, 721A	2
32	Receiver	Collins, 515-1	2
33	Directional Coupler	Sierra, 150	2
34	Attenuator	Hewlett-Packard, 355C	3
35	Attenuator	Hewlett-Packard, 355A	1
36	Walkie-Talkie	Johnson, 242102	3
37	Transceiver	Midland, 13-136	2
38	Transceiver	Vocaline, ED-27M	2
39	Battery Charger	SRIS Mfg.	1
40	Camera	Kodak, III	1
41	Camera	Nikon, F	1
42	Attenuator	Hewlett-Packard, 355B	1
43	Equalizer	CEC, 13-349-1	5
44	Equalizer	CEC, 13-349-3	2

Table A-1. Telemetry Equipment (Cont.)

ITEM	DESCRIPTION	MANUFACTURER & MODEL NO.	QTY
45	Recording Paper	CEC, 465124-5502	40
46	Direct Reproduce Unit	Precision Instruments, 10220-004	6
47	Direct Reproduce Unit	Precision Instruments, 10220-003	1
48	Magnegausser	Ampco, 200C	1
49	Coax Cable	RG-8, 50' roll	3
50	Power Supply	Kepco, 721A	2
51	Speaker Console	Collins, 312B-5	2
52	Receiver	Vocaline, ED-27M	2
53	Magnetic Tape		
54	Gage Antenna		4
55	Helix Antenna	NMSU, 21.004	2
56	Coax Cable		
57	Power Cable		
58	Transformers	Westinghouse, DT-3	2
59	Tool Box (NZ)	(Inventory available SRIS files)	2
60	Assorted tubes, transistors, resistors, capacitors, connectors, and cable lengths.		

Table A-2. Experiment Equipment

ITEM	DESCRIPTION	MANUFACTURER & MODEL NO.	QTY
1	Power Amplifier	Collins, 367A3	2
2	Voltmeter	Hewlett-Packard, 410B	1
3	LC Meter	Tektronix, 130	1
4	Power Supply	Collins, 428B-1	1
5	Blower	Collins, 199G-3	1
6	Power Supply	Hewlett-Packard, 721-A	4
7	Receiver	Heathkit, GC-1A	1
8	Electronic Counter	Hewlett-Packard, 5245L	1
9	Frequency Converter	Hewlett-Packard, 5261A	1
10	Wattmeter Dummy Load	Waters, 334	2
11	Plug In Unit	Tektronix, L	2
12	Plug In Unit	Tektronix, CA	2
13	Generator Low Frequency	Hewlett-Packard, 202A	1
14	Oscilloscope	Tektronix, RM43A	1
15	Signal Generator	Hewlett-Packard, 606A	3
16	Power Supply	Hewlett-Packard, 712B	1
17	RX Meter	Boonton, 250A	1
18	Receiver	Collins, 51S	1

Table A-3. Cargo and Performance Characteristics, C-124 Transport

Aircraft Type	Douglas C-124
Length	130 feet
Span	174 feet
Gross Weight	185 000 pounds
Design Payload/Range	50 000 lbs/870 n.mi.
Payload/Range (Typ):	
37 000 lbs.	2000 n.mi.
24 000 lbs.	3000 n.mi.
11 000 lbs.	4000 n.mi.
Cargo Size:	
Floor Area	983 sq. ft.
Floor Dimensions	74 ft. long x 12.8 ft. wide
Loading Door	11.7 ft. high x 11.3 ft. wide
Volume	10 000 cu. ft.
Take-off Distance	3600 ft.
Landing Distance	1940 ft.

APPENDIX B

ARCAS TELEMETRY TRANSMITTING ANTENNA SMITH CHART PLOTS AND RADIATION PATTERNS

Figures B-1 through B-3 of Appendix B contain sample Smith chart plots of telemetry antennas flown on Arcas New Zealand flights. Figures B-4 through B-10 contain typical radiation patterns measured at intervals of 30° Ø as determined on the standard spherical coordinate reference system. Measurements were taken with each antenna enclosed by a standard ARC No. 8 ogive nose cone constructed of G.E. textolite epoxy conforming to NEMA grade G-10.

IMPEDANCE COORDINATES—50-OHM CHARACTERISTIC IMPEDANCE

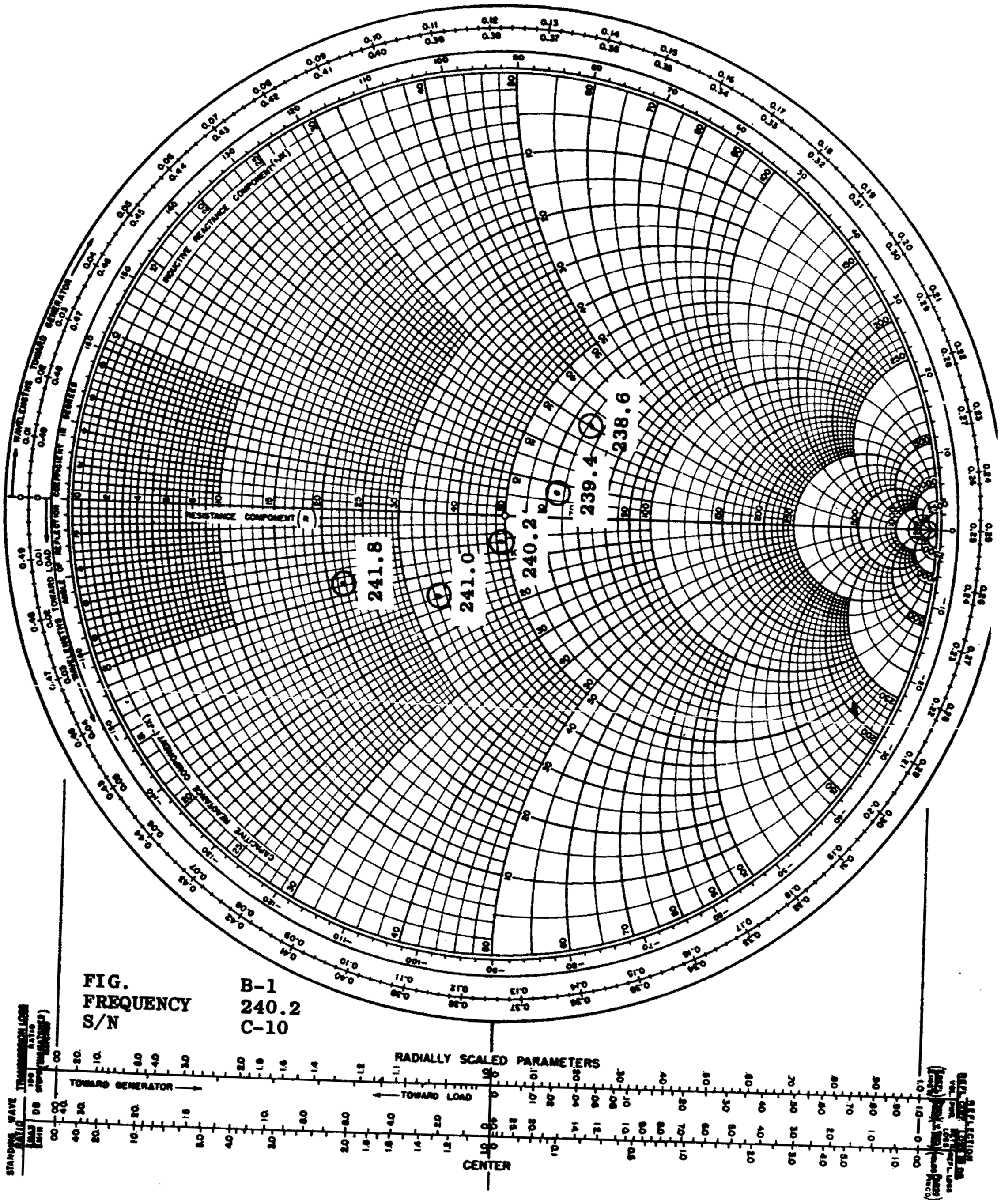


FIG. B-1
FREQUENCY 240.2
S/N C-10

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IMPEDANCE COORDINATES—50-OHM CHARACTERISTIC IMPEDANCE

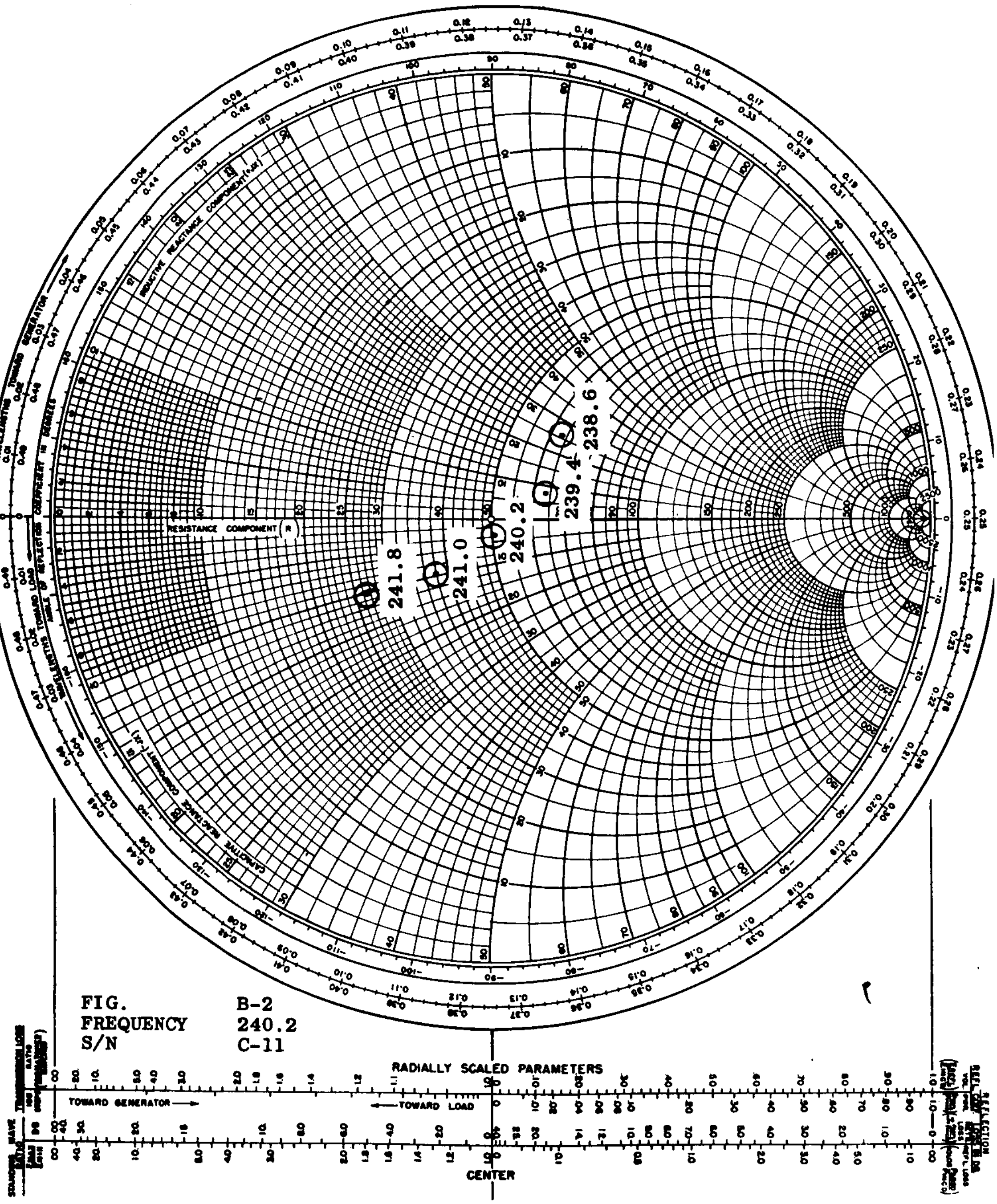


FIG. B-2
FREQUENCY 240.2
S/N C-11

IMPEDANCE COORDINATES—50-OHM CHARACTERISTIC IMPEDANCE

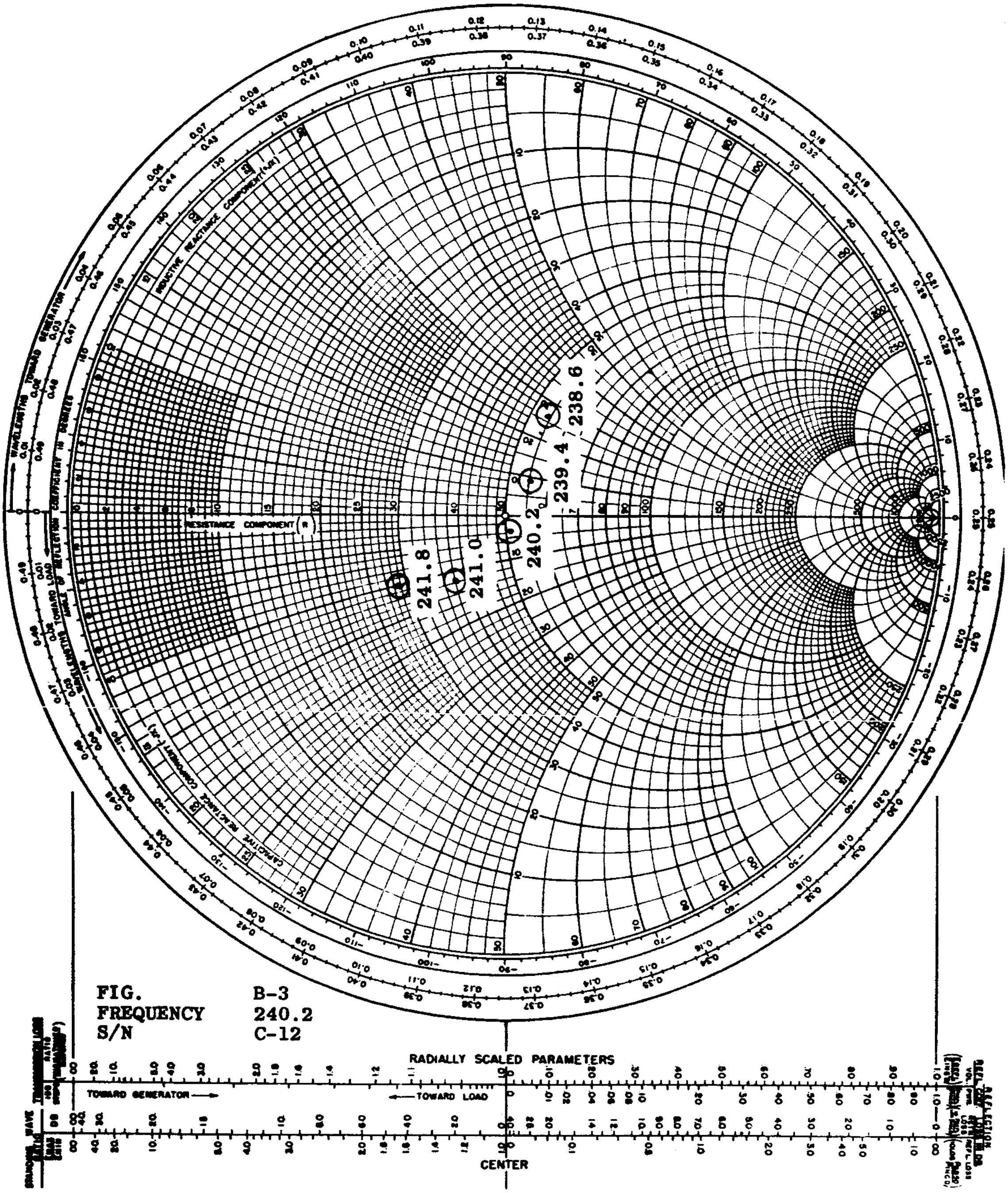


FIG. B-3
FREQUENCY 240.2
S/N C-12

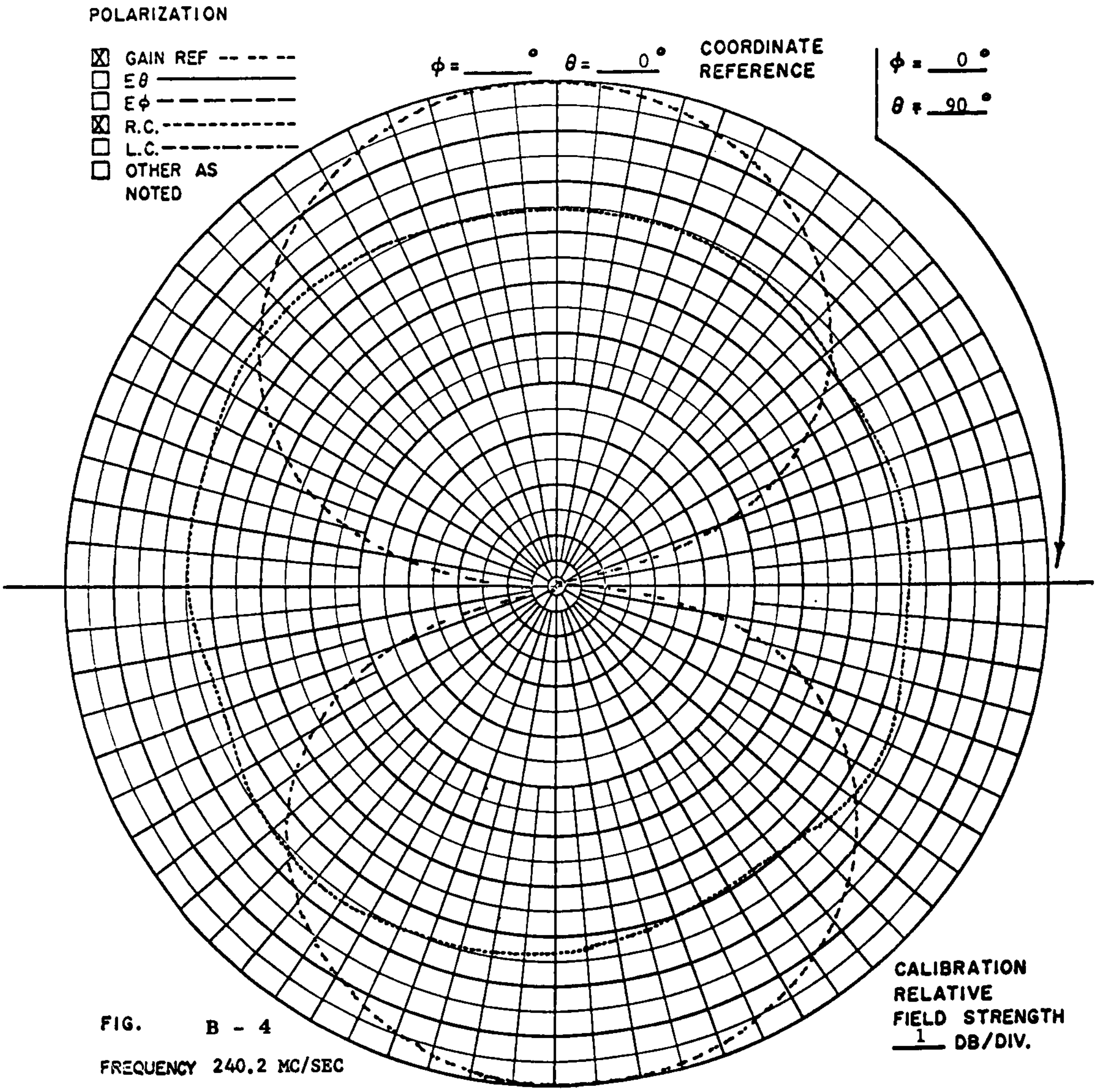


FIG. B - 4

FREQUENCY 240.2 MC/SEC

ANTENNA MODEL 24.003 FOR ARCAS ROCKET

REMARKS THE GAIN AT Θ = 180°, Ø = 0° IS -5.5 DB WITH RESPECT TO A STODDART HALF-WAVE DIPOLE.

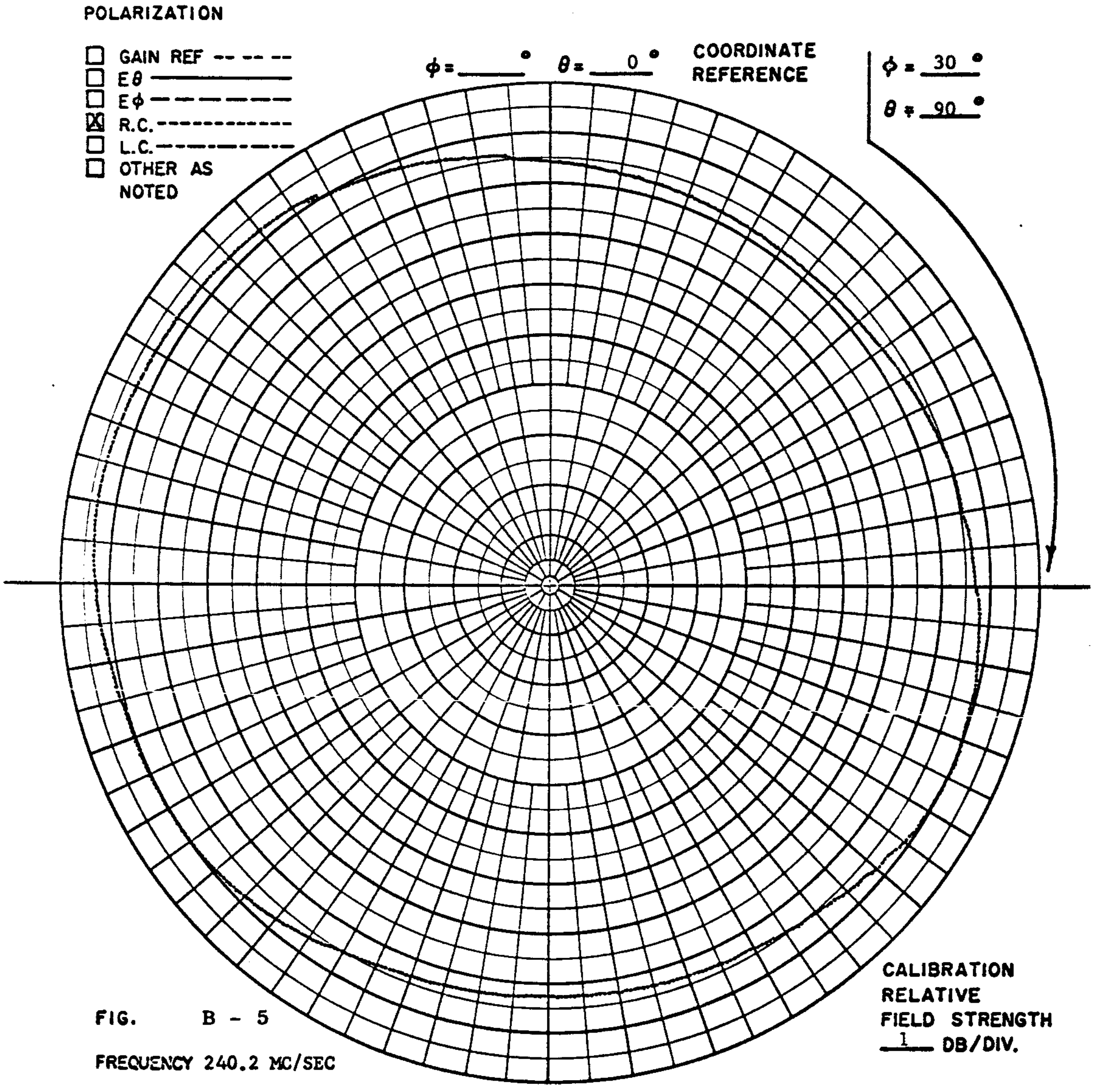


FIG. B - 5

FREQUENCY 240.2 MC/SEC

ANTENNA MODEL 24.003 FOR ARCAS ROCKET

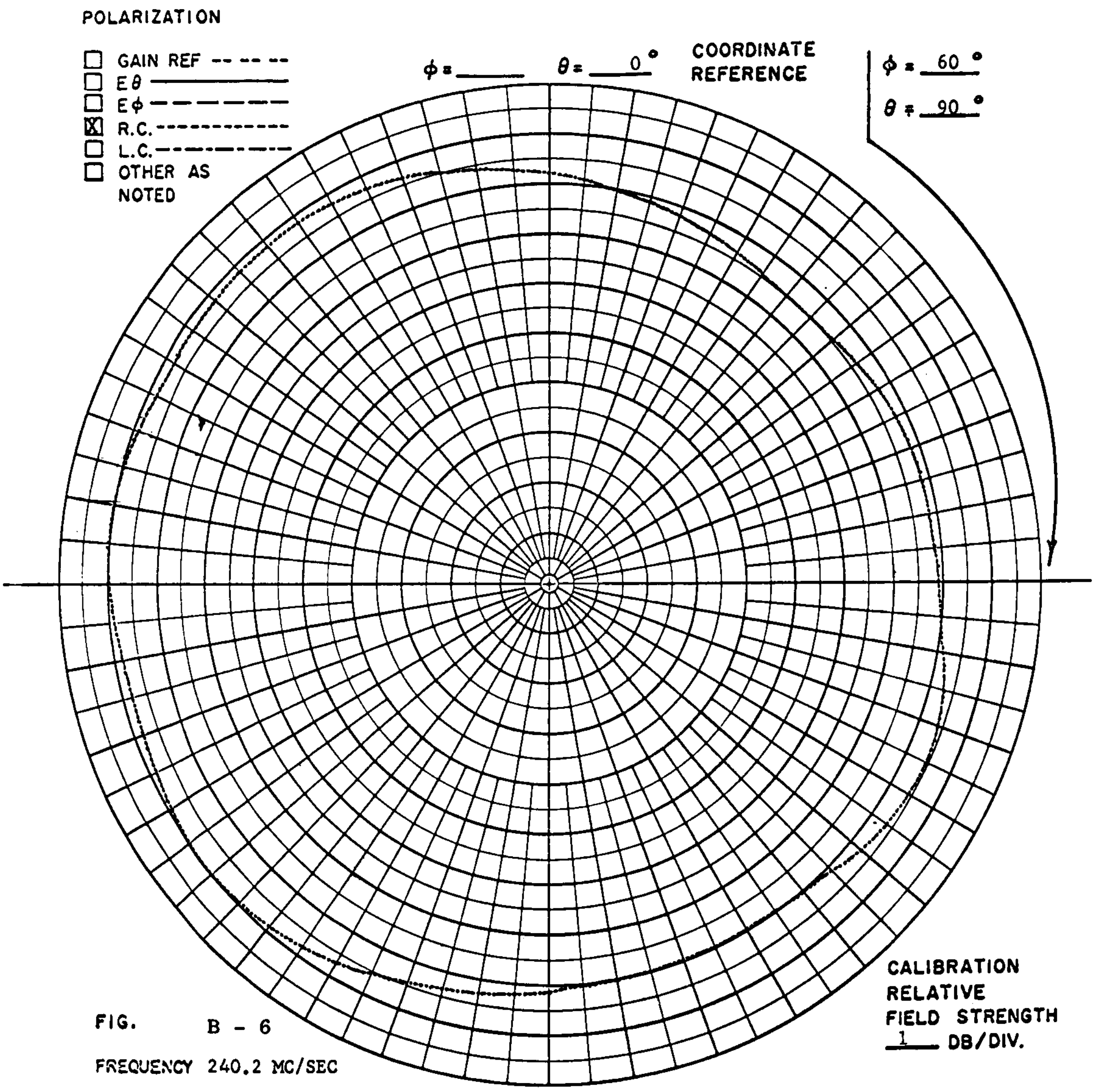


FIG. B - 6

FREQUENCY 240.2 MC/SEC

ANTENNA MODEL 24.003 FOR ARCAS ROCKET

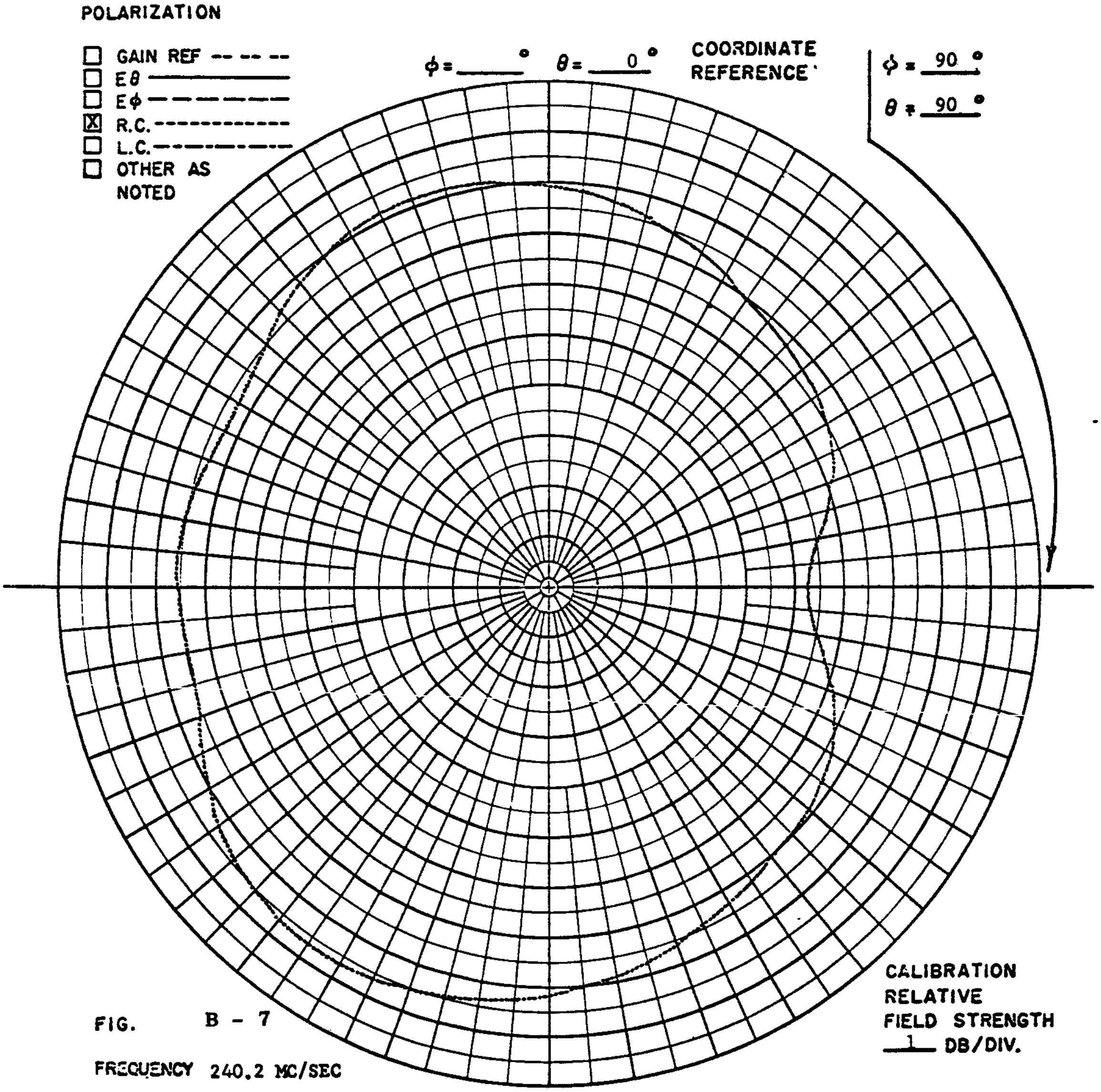


FIG. B - 7

FREQUENCY 240.2 MC/SEC

ANTENNA MODEL 24.003 FOR ARCAS ROCKET

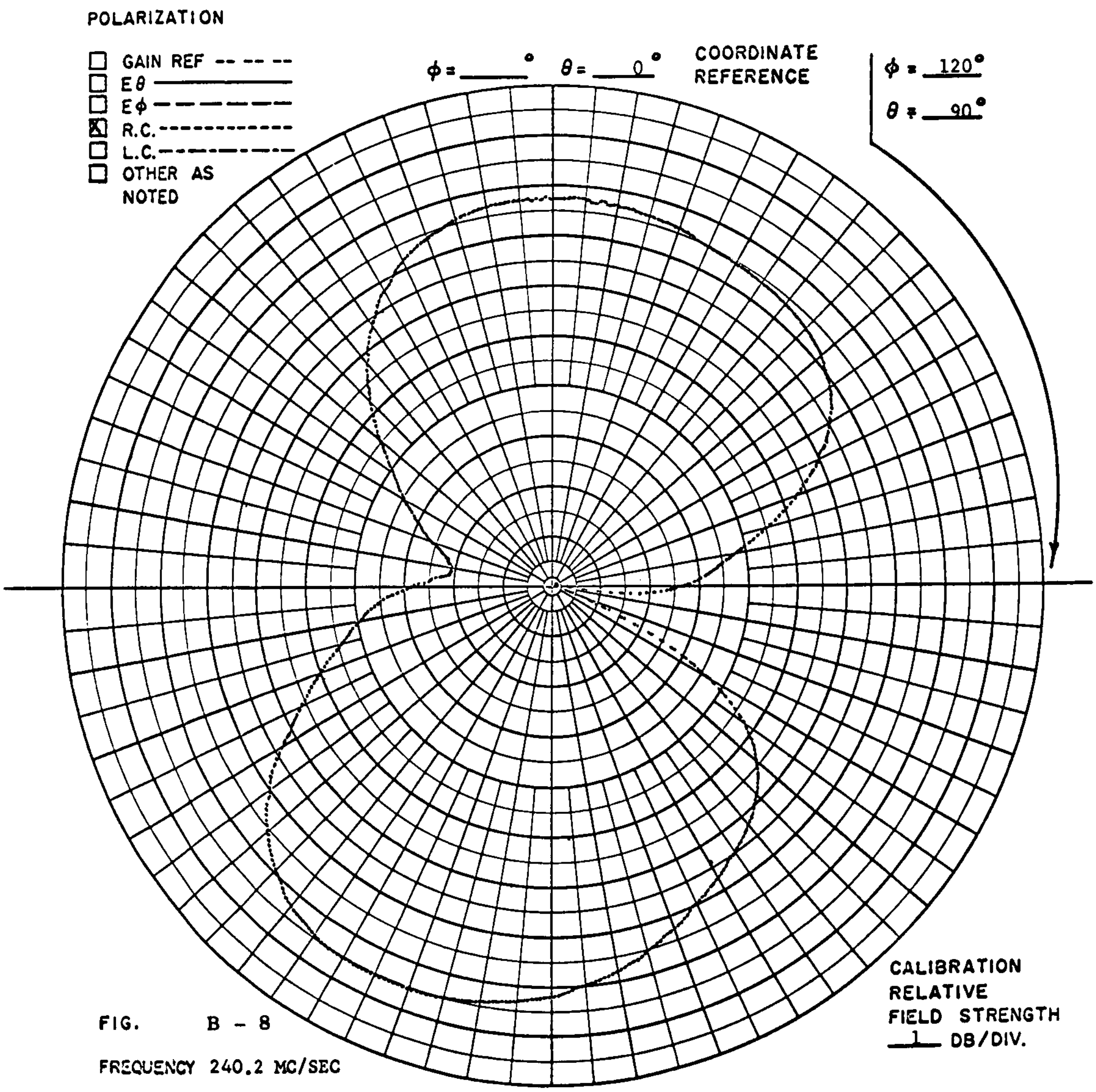


FIG. B - 8

FREQUENCY 240.2 MC/SEC

ANTENNA MODEL 24.003 FOR ARCAS ROCKET

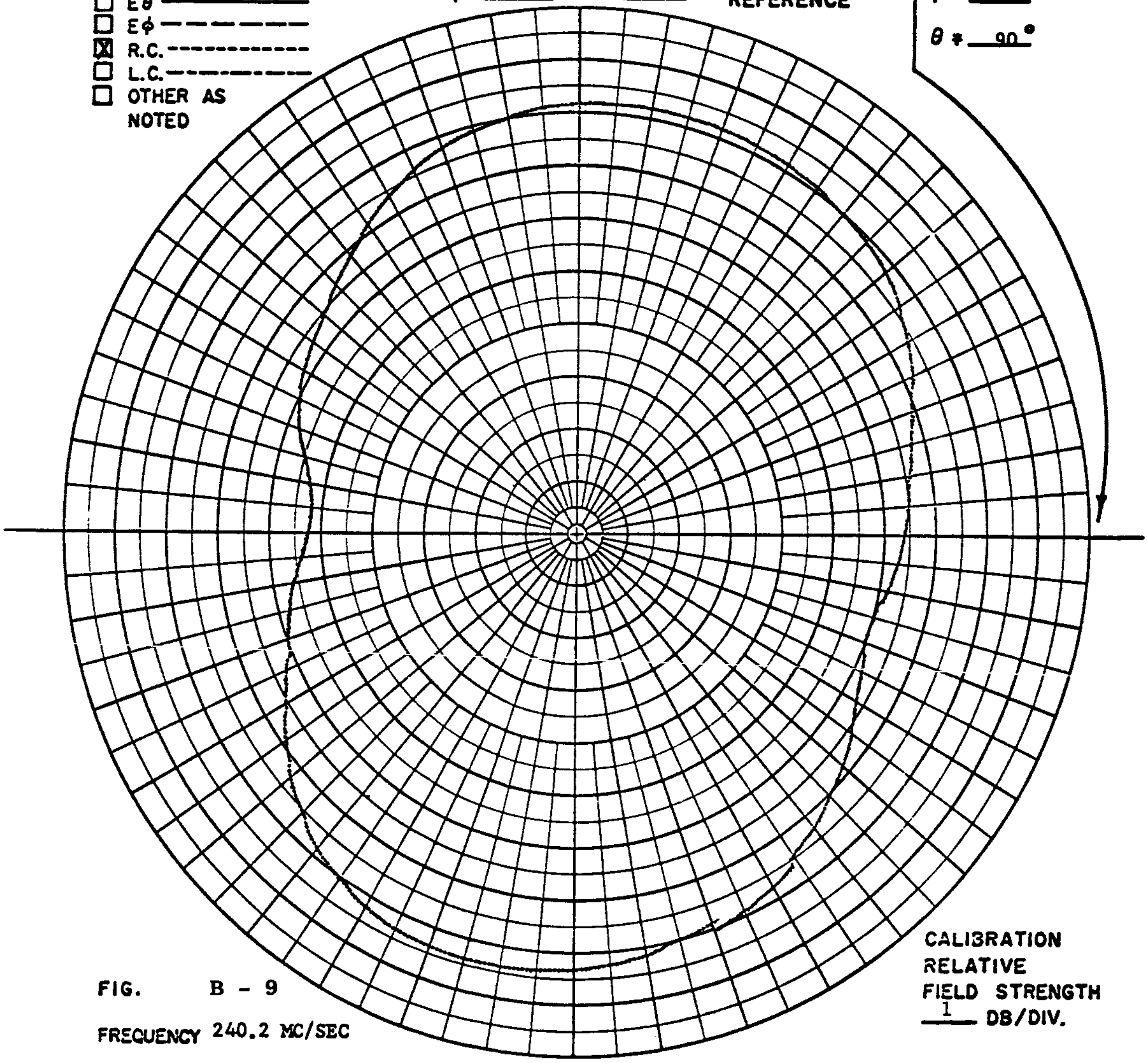
POLARIZATION

- ☐ GAIN REF -- -- --
- ☐ Eθ ————
- ☐ Eφ — — — —
- ☒ R.C. ------------
- ☐ L.C. —-—-—-—
- ☐ OTHER AS NOTED

φ = ____° θ = 0° COORDINATE REFERENCE

φ = 150°

θ = 90°



CALIBRATION RELATIVE FIELD STRENGTH 1 DB/DIV.

FIG. B - 9

FREQUENCY 240.2 MC/SEC

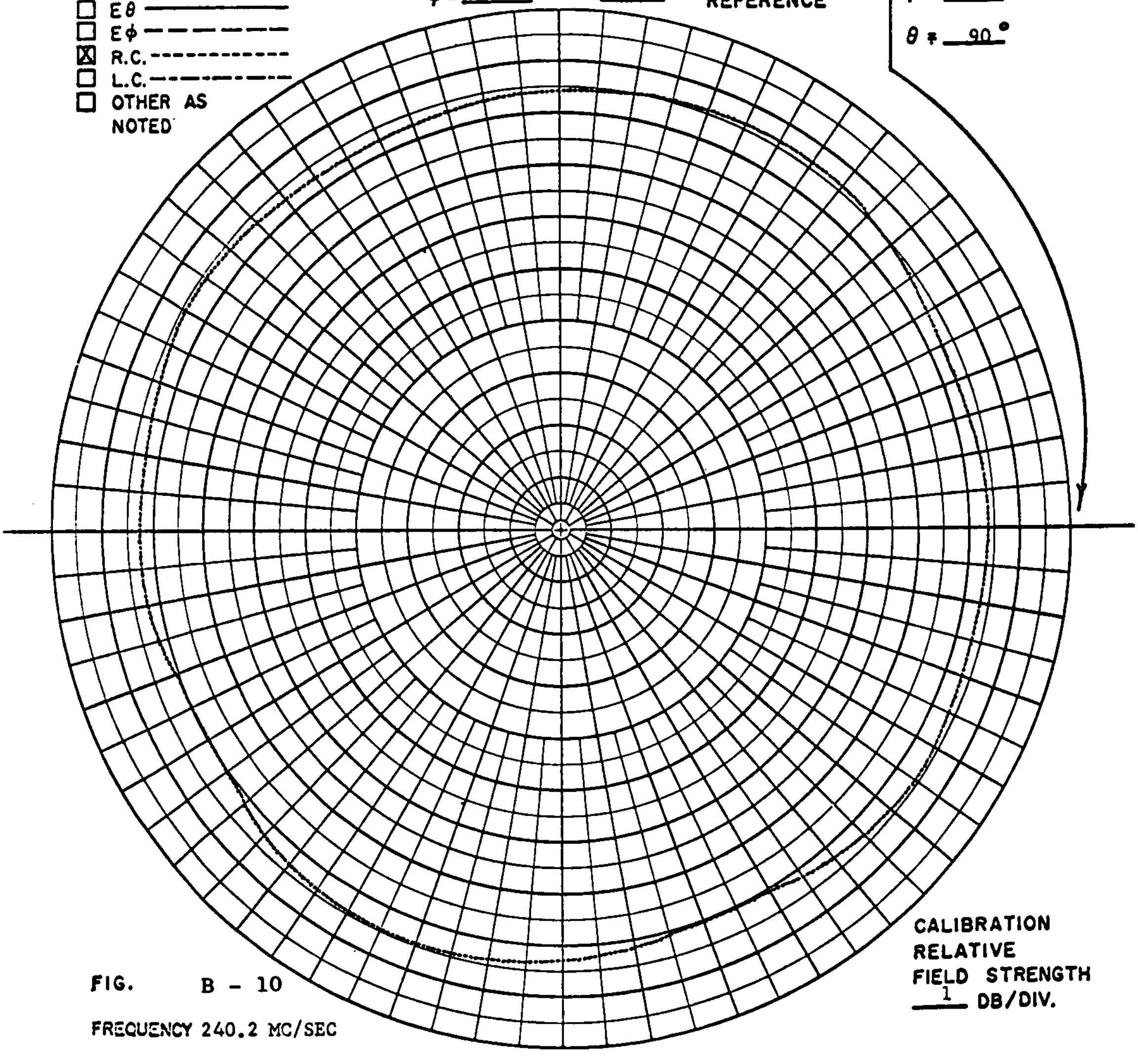
ANTENNA MODEL 24.003 FOR ARCAS ROCKET

POLARIZATION

- ☐ GAIN REF
- ☐ Eθ
- ☐ Eφ
- ☒ R.C.
- ☐ L.C.
- ☐ OTHER AS NOTED

φ = ____° θ = 0° COORDINATE REFERENCE

φ = 180°
θ = 90°



CALIBRATION
RELATIVE
FIELD STRENGTH
1 DB/DIV.

FIG. B - 10

FREQUENCY 240.2 MC/SEC

ANTENNA MODEL 24.003 FOR ARCAS ROCKET

APPENDIX C

KAITAIA RANGE ORDERS

Appendix C, extracted from a document compiled for the guidance of RNZAF personnel, describes general range requirements and delineates areas of responsibility for preparation and flight of Arcas rockets launched during the Solar Eclipse Project. The following parts are included:

		Page
C-1	Kaitaia Range Orders	C-3
C-2	Scientific Project Coordinator Directive	C-9
C-3	Range Safety Officer Directive	C-10
C-4	Launch Officer Directive	C-11

PART C-1. KAITAIA RANGE ORDERS

GENERAL INFORMATION

1. Location and Description of Range. The launching site is located on the East coast of the North Island South of Cape Karikari in Matai Bay at latitude 34° 49' 30" South and longitude 173° 24' 19" East. The inland range danger area is enclosed in a circle of one mile radius centered on the launch site. The seaward range is contained in a 60 degree sector centered on the launch site and extends seaward for 50 miles. The seaward range boundaries are defined by lines drawn through the launch point of 002° T and 062° T. The local danger area is to be 200 yards radius from the launch pads.

2. Range Authorization, Limitations. The range is authorized for use between May 26 and May 31, 1965, in conjunction with scientific observations which will be carried out during the solar eclipse on the morning of May 31. Rockets may be fired between 0600 hours and 0930 hours on the following days:

(a) 26 and/or 28 May; practice firings.
(b) 31 May; during solar eclipse.

3. Type of Rocket Vehicle. The Kaitaia Range is authorized for the launching of Boosted Arcas high altitude research rockets.

4. Facilities. When in operation the range will have the following facilities:

(a) Launch pads and Launchers. Launch pads consisting of two concrete pads 12 feet square and 8 inches thick, at least 150 feet apart are to serve as mountings for two Arcas Ex. 120 Rocket Launchers.

(b) Launch Control Post (LCP). The LCP is to be sited not less than 200 yards from the launch pads and provide the following facilities:

(i) Communications Center
(ii) Wind Indicating Instruments
(iii) Firing Console

(c) Rocket Vehicle Preparation Area. An open ended temporary structure sited adjacent to the launch control post.

(d) Rocket Vehicle Storage Area. A separate rocket vehicle storage area is to be made available and sited not less than 200 yards from the launch pads.

(e) Scientific Sites

(i) NASA Telemetry Van
(ii) Canterbury University Caravan.

ORGANIZATION AND ADMINISTRATION

5. Operational Control and Responsibilities. Individual responsibilities for the operational control of the range are detailed as follows:

(a) Scientific Project Coordinator - Part C-2.

(b) Range Safety Officer (RSO) - Part C-3.

(c) Launch Officer - Part C-4.

6. Launch Schedules. Launch schedules are to be prepared by the Project Coordinator, with the assistance of the RSO, Launch Officer, and scientific staff as necessary. The schedules are to contain full particulars of all phases of the operation, including countdown procedure and the coordination of scientific observations.

7. Advice of Rocket Launchings. Firing intentions are to be confirmed with RNZAF Headquarters two days before firings are due to take place. Advice is also to be forwarded as soon as possible after firing has been completed. Local authorities, Marine Department, Civil Aviation, Police, landowners concerned, and the general public are to be given adequate warning of firing intentions.

RANGE SAFETY ORDERS

8. Entry of Personnel. When a rocket firing program is being carried out, only those persons employed on the project, or special visitors approved by the Project Coordinator, are permitted inside the range danger area. When a rocket launching is imminent all personnel are to be outside the local danger area.

9. Guards. When the range is in use, guards are to be posted to prevent unauthorized entry into the range danger area.

10. Danger Notice. A danger notice reading "Danger Rocket Firing" is to be positioned at the point of entry to the range.

11. Fire Fighting and First Aid.

(a) Fire fighting facilities are to be available during range operations.

(b) All inflammable material is to be cleared for a distance of 100 yards from the launchers.

(c) Smoking is prohibited inside the local danger area when the range is in use and at all times in the vicinity of the rockets or boosters.

(d) A medical orderly in possession of a first aid kit is to be available during rocket launching operations.

12. General.

(a) No structure is to be within 100 yards of the rocket launchers and a 60° quadrant in the direction of rocket flight is to be kept completely free of obstructions.

(b) All motor vehicles are to be outside the local danger area when rocket firing is in progress.

LAUNCH PAD SAFETY ORDERS

13. Handling, Preparation, and Loading. The following safety orders are to be observed at all times during the handling, preparation, and loading of rockets:

(a) During loading operations the rocket launchers are to be pointed in a safe direction.

(b) The number of persons engaged in the preparation of rockets and loading operations are to be kept to a minimum.

(c) No electrically powered tools are to be used.

(d) The firing leads are to be shunted and also disconnected at the launcher.

(e) The safety switch on the firing console is to be in the OFF position and the key retained by the Launch Officer.

(f) The preparation of rockets is to be carried out in the designated area only.

14. Launcher Settings Limit. The rocket launcher is not to be aimed or fired at settings outside the following limits:

(a) Maximum elevation, 88°

(b) Maximum azimuth, 30° either side of range center line.

(c) The planned impact area is to be such that the whole dispersion area is within the boundaries of the range danger area.

LAUNCH PROCEDURES

15. The erection and setting up of the launchers and the preparation and loading of rockets is to be carried out in accordance with the procedures detailed in the appropriate Arcas Manuals. The following paragraphs give additional details on some procedures, or emphasize particular points.

16. Launcher: Preloading Checks. Prior to loading a launcher, the following checks are to be carried out:

(a) Examine for security.

(b) Ensure that the 13.12-inch plug gauge passes through the full length of the launcher tube.

(c) Ensure that the inside of the tube is clean and lubricated.

(d) Check that the firing line to the launcher is serviceable.

17. Preparation of Rocket and Booster

(a) Handling

(i) The rocket motor and/or assembled rocket is to be handled by two men at all times. When the booster is assembled to the rocket, a third man is required to support this section.

(ii) The fins of the rocket are very delicate and their precise alignment is essential for successful rocket performance. All handling is to be done by grasping the rocket and booster bodies.

(iii) Extreme care must be taken in handling to ensure that the fins do not strike, or are struck by, any object. If the fins are damaged during handling or if the rocket or booster is dropped, do not attempt to launch the rocket.

(iv) Observe all applicable safety orders.

(b) Inspection of Components. Inspect the rocket motor, booster, and components as follows:

(i) Visually inspect for evidence of mishandling.

(ii) Check that the fins are not bent or nicked. Chipped paint on the fins can be evidence of damage.

(iii) Test the ignitors with a safety ohmmeter and check that the resistance is as follows:

a. Booster ignitor - 0.7 to 1.4 ohms

b. Rocket ignitor - 1.0 to 1.3 ohms

<u>NOTE</u>: To shield the person carrying out the tests, the ignitors are to be placed behind a suitable protective wall. The ignitors are not to be checked in the immediate vicinity of the rockets.

(c) <u>Assembling Payload to Rocket Motor</u>. When the payload is assembled to the rocket motor prior to launching, the assembled rocket is to be checked to ensure that:

(i) The payload is securely attached.

(ii) The C.G. is within the prescribed limits.

18. <u>Aiming the Launcher</u>. The launcher is aimed to allow for wind effect. The necessary settings which are calculated during the preparation and loading of the launcher are made as follows:

(a) When loading is completed and launcher settings are confirmed, the Launch Officer sets the launcher as directed.

(b) The Launch Officer's assistant then checks the settings and confirms with the LCP that they are correct.

19. <u>Final Preparation for Firing</u>. When the launcher is loaded and aimed and all is in readiness for launching, all personnel except the Launch Officer leave the launch pad and move outside the local danger area. The Launch Officer then connects the firing line at the launcher at the appropriate time in the countdown and retires to the LCP.

20. <u>Prelaunch Checks</u>. Before any launching instructions are given, the RSO is to ensure that:

(a) All necessary safety orders have been observed and the range is clear.

(b) That the surface wind conditions are satisfactory.

(c) That fire fighting and first aid facilities are immediately available.

21. Firing the Rocket. When clearance is given to proceed with the firing, the Launch Officer produces the key to the safety switch and at T-30 seconds turns the switch on. The countdown proceeds and at "Fire" the firing switch is operated.

22. Misfire Procedure. In the event of a misfire the following procedure is to be followed.

(a) Turn off the safety switch and remove the key. This is to be retained in the Launch Officer's possession until the misfire has been cleared.

(b) Wait one hour before approaching the launcher.

(c) Disconnect the firing line and shunt the rocket and booster ignitor leads.

(d) Unload the rocket from the launcher.

PART C-2. SCIENTIFIC PROJECT COORDINATOR DIRECTIVE

The Scientific Project Coordinator is responsible for:

(a) The overall direction of the scientific and rocket firing program.

(b) Preparation of the Launch Schedules as detailed in para. 6 and general supervision of the countdown procedure.

(c) Obtaining meteorological forecasts, calculating wind effect, and advising the RSO of launcher settings and predicted trajectory details prior to launching.

(d) Ensuring that scientific equipment is functioning as required and advising the RSO that launching may proceed.

(e) Ensuring that scientific staff are aware of and comply with Range Safety Orders and Launch Pad Safety Orders as applicable.

PART C-3. RANGE SAFETY OFFICER DIRECTIVE

1. The Range Safety Officer is responsible to the Commanding Officer Hobsonville for:

(a) The command and organization of the RNZAF and the scientific staff.

(b) Liaison as required between the RNZAF and the scientific staff.

(c) General security of the range including precautions against trespassing while the range is in use and the safeguarding of equipment.

(d) The availability of fire fighting and medical facilities while the range is in use.

(e) Ensuring that Range Safety Orders and Launch Pad Safety Orders are known and understood by all personnel concerned and that they are complied with.

2. The RSO is also responsible in conjunction with the Project Coordinator for:

(a) Advice to RNZAF Headquarters, and any other interests as listed in para. 7 of these orders, of intended rocket firings.

(b) Control of countdown procedures in accordance with the launch schedule.

(c) Ensuring that all prelaunch checks are completed before advising the Launch Officer that firing may proceed.

PART C-4. LAUNCH OFFICER DIRECTIVE

The Launch Officer is responsible to the Range Safety Officer for:

(a) Receipt from storage at RNZAF Station Hobsonville of Arcas rockets and transportation to the Kataia Range.

(b) Compliance with all regulations governing the transportation of explosives by road.

(c) Transporting the Arcas rocket launchers and installation on the site.

(d) Supervision of RNZAF launch crew and rocket handling crew.

(e) Preparation and orientation of the rocket launcher for rocket firing, in conjunction with the scientific staff.

(f) Preparation, loading, and launching of Arcas rockets in accordance with the launch schedule.

(g) Liaison with the scientific staff in all matters concerning preparation and launching.

(h) Compliance of Range Safety Orders and Rocket Pad Safety Orders.